AMERICAN SOCIETY OF CIVIL ENGINEERS.
INSTITUTED 1852.

TRANSACTIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

710.
(Vol. XXXI.—June, 1894.)

ADDRESS AT THE ANNUAL CONVENTION AT THE CATARACT HOUSE, NIAGARA FALLS, N. Y., JUNE 20TH, 1894.

By WM. P. CRAIGHILL, President Am. Soc. C. E.

Gentlemen of the Am. Soc. C. E.—Our Constitution prescribes one duty for the President of the Society in a very explicit and mandatory manner. It says: "He shall deliver an address at the Annual Convention." Fortunately, the length of the address is not defined. I feel at liberty, therefore, to make mine very short. It will thus have at least one merit.

Here I may remark, for the benefit of my successors, that I doubt the expediency of requiring the President of the Society to make an address on this occasion, and I would suggest a change in the phraseology of the Constitution, so that it will read "he may deliver an address at the Annual Convention," and not "shall."

After casting about for a subject, I have decided to give you some thoughts about our national defences, and to refer in the beginning to some erroneous ideas which have prevailed and do prevail among many of our people. I will first indulge in a little ancient history.

When the great civil war came on, the sea-coast defences of this country, so far as the system had been carried out, were admitted to be as good as any in the world. They were built to resist naval attacks, and with that object their general plan and detailed arrangements were excellent. The character of the materials and workmanship was not surpassed by any.

In a certain particular, one of the greatest importance, the arrangement was better than that possessed by any other people. I refer to what is called the Totten embrasure. The embrasure, as you are aware, is the opening in a defensive wall through which a large gun is fired. Without going into the details of the Totten embrasure, I will call your attention to one great improvement it introduced. While in a casemated battery built for the defence of a great European port, just before the introduction of the Totten embrasure in this country, the opening in the wall was 54 sq. ft., and allowing the gun a horizontal traverse of only 40°, the Totten embrasure gave an opening of only 9 sq. ft., while the gun had a horizontal traverse of 60°, and as much elevation and depression as were necessary. The wall around the throat of this embrasure was strengthened by the insertion in the masonry of 1 ft. in thickness of wrought iron, and there was used also lead concrete, which was found to be a most excellent material for resisting the impact of shot, and could be readily introduced into irregular spaces in the masonry.

Shutters of wrought iron were also added, so arranged as to be open only when the gun was ready to be fired, and of such a thickness as to exclude missiles as large as grape shot. The shutters were provided with springs on the backs so as to close spontaneously under the effect of the impact of the explosion caused by the firing of the gun. The smoke from the discharge was also excluded by them. This invention of General Totten, who was then Chief of the Corps of Engineers of the Army, is of historic interest as the first instance of the use of iron plating on land batteries.

Some of these old masonry forts containing these admirably arranged embrasures are still of value, though they are by no means to be entirely depended upon for the defence of our harbors. But they are still useful, as I will try to explain.

A very important part of our present system of defence consists of torpedoes, and these should be under fire to be of any value; other-

wise an enemy could readily remove or disable them. The vessels that would be chiefly used to remove or disable torpedoes would be the lighter craft which would be quite vulnerable under the fire of such guns as the Totten embrasure will still accommodate well.

An attacking fleet will not consist wholly of great ironclads. These will be met by our heaviest guns and mortars mounted behind impenetrable covering masses, and made as safe as possible by the use of hydraulic lifts, disappearing carriages, etc., but it would be a waste of energy and money to fight the smaller craft with these largest guns.

An interesting lesson for our day may be learned from the attack of the British on Baltimore in the war of 1812. On that occasion troops were landed from the fleet at North Point, about 12 miles below, and moved upon the city. Simultaneously the fleet attacked Fort McHenry, which was at that time the main defensive work for the harbor and situated on the outskirts of the city. But this was not all. The British Admiral, under the cover of night and the smoke of his bombardment, sent a number of small boats past the fort, filled with quite a force of men, who were expected to land in its rear and attack it from that quarter. Fortunately, the Americans had several small guns in a retired battery, and from this position the boats, which had safely passed the main line of defence, were fired upon, some of them sunk, and their occupants so demoralized that they retired in confusion. This was the crisis. When this boat attack failed, the fleet withdrew, the troops fell back and re-embarked, and the attack was abandoned.

So, in our day, prudence and economy require the use of many comparatively small guns suitably located, and they will be found most efficient and valuable for the purposes indicated.

The fall of Fort Sumter led to grave misapprehensions which still exist in many minds. The walls of this fort were of concrete, with an interior and exterior facing of brick. It was built to fight guns afloat and not guns ashore. It had been a principle of the art of fortification from the time of Vauban and Cormontaigne that masonry should never be exposed to the fire of land batteries. It was never expected that Fort Sumter at Charleston or Fort Pulaski on the Savannah River would be assailed from the land and from the rear, as they both were.

And it is a remarkable thing that Fort Sumter never surrendered

because of the fire of guns upon it either from the land or from ships. In the first attack upon it by the Confederates the defensive properties of the fort were not impaired and nobody was hurt. Major Anderson had no provisions and would have been obliged to surrender in a day or two if he had not been fired upon at all.

Fort Sumter was next assailed by the United States fleet under Dupont, which was iron-clad and the most powerful which had ever made an attack up to that time. After a gallant fight he withdrew, finding, as the report says, "no impression made upon the fort." The Admiral says, "in the brief though fierce engagement five out of the eight iron-clads were disabled, and a half-hour more of fighting would, in my judgment, have placed them all *hors de combat.*" It should be observed, too, that while the armament of the fleet was of the best of that day, the armament of the fort was not at all so.

Admiral Dahlgren succeeded Dupont in the command of the fleet before Charleston. He lay off the harbor for months, but never ventured on another attack; for Sumter had done what it was built to do—it had fully repelled the attack of a powerful fleet.

Later in the war Fort Sumter was much knocked to pieces by the batteries on the land and in its rear, but it was still capable of defence and was never actually captured. When Charleston surrendered after Sherman's march, Fort Sumter was surrendered with it, but it was not captured.

I was at Fort Sumter not a very long time ago. It is still valuable as a strong position against a naval attack, and will prove my assertion true if ever we are assailed by a foreign foe.

Many people think that we should strive for invulnerability in our forts. They are mistaken. The question is one of relative vulnerability and endurance, and in these particulars the advantage will be always on the side of the defence. No matter how much armor is put on ships, we can always put more on the land batteries. We can mount the same guns on shore much more cheaply than on ships, and on shore we have the great advantages of stability, accuracy of fire, and other things which are unattainable afloat.

The successes of Farragut at Mobile and New Orleans have also been much misunderstood. It is a principle of the defence of any place by forts against ships that the enemy should not be allowed to find any spot along the nearer approaches to the object to be defended,

or within extreme cannon range of it, where he will not be himself exposed to a powerful fire of many guns of the heaviest calibres, and there should also be an abundance of torpedoes over all these areas, fully protected by suitable guns bearing upon them. The defences of Mobile and New Orleans had never been completed. When Farragut had boldly passed the outer line at each place, he was no longer under a fire of any importance. The victory was won.

The contest for supremacy still continues between guns and armor. The day may come when to protect ships sufficiently to enable them to resist the shots of the most powerful guns, will make them so heavy as to be too unwieldy. To undertake to plate the decks so heavily, as well as the sides, would certainly have that effect. And to leave the decks unplated, as is practically the case at present, makes the ships very vulnerable to the missiles of the large rifled mortars, the accuracy of whose fire has greatly increased.

The time may come when, as the knights of old threw off their cumbersome armor upon the invention of gunpowder, ships will be left unarmored, and will trust in their speed and heavy guns, of which they could then carry a greater number. We may all come to the practical adoption of the saying attributed to the great admiral, Farragut, "broadsides rather than ironsides." In truth, the first-class armored warship of the present day has become a most unwieldy monster, full of the most intricate machinery. We all remember the frightful disaster to the British ship *Victoria*, which was sunk by her companion, the *Camperdown*, in the Mediterranean Sea. In 1893 six other ships of war were lost, and but one of them in actual war.

A very high authority, Mr. Cramp, the eminent ship-builder, has lately expressed the following opinion: "The most important fact of all is overlooked or not understood by the general public. All armored construction proceeds upon the admitted supremacy of the gun. No one conversant with the situation expects armor to be invulnerable.

"Naval architects do not pretend to make an impenetrable ship.

"They only try to do their best within fixed limits of the carrying capacity of the ship. The gun always has the advantage. The gun can never have so much the advantage when afloat as it has at the testing-ground" or ashore.

No armor has yet been produced that can properly be called invulnerable; and it is reasonably safe to say that no such armor ever will

be produced, notwithstanding the strengthening due to the process of Harvey.

Having referred briefly to some things in the past, let me now dwell a little while on the present.

Let us ask ourselves what is a proper system of defence for our country, situated as we are, with a very small standing army, a very large territory not densely populated, a very long coast line, and our eastern and western sections separated from each other by wide, barren tracts of land and high ranges of mountains.

Some would say that we need neither forts nor ships, that no enemy would undertake to land an army on our shores, as our militia would rise up and drive the invaders into the ocean or capture them all. The people holding such opinions are generally those who dwell in the interior and are little likely to be attacked by anybody, or to have their property seized or destroyed. It is true the militia of the country are as brave as any men, and when converted into veterans by the discipline and experience of actual service make as good soldiers as any in the world, as our great civil war proved, and as had been demonstrated in the Mexican and previous wars. But the appearance of a foreign army in our midst must be preceded by a landing on our coast somewhere, unless it come from Mexico or Canada. We can very well trust to our army of militia to take care of an invasion by land. In case, however, of an attempt at a descent upon our coast, a proper resistance could not be made by the militia alone, however brave and well-disciplined they might be. They could make no prolonged resistance to the big guns of an invading fleet. The more men lined the shores, armed with the best rifles and with field artillery, and even if provided with Herr Dowe's bullet-proof coats, the greater would be the slaughter and disaster.

It may be safely concluded that for security against invasion we must have something more than the army to depend upon. We need something to keep an enemy's ships carrying the largest long-range guns, at such a distance from our vulnerable points as to have them secure.

The object of an enemy is always to do the most damage he can to his adversary with the least harm and danger to himself. The most valuable and easily accessible objects of an enemy's cupidity are our great cities and naval establishments on or near our coasts. And as

such establishments are generally located on the finest harbors, they become thereby most easily accessible by the largest ships of an enemy. How shall they be made secure?

We might resort to the most obvious method, to fill up the channels of approach by such obstructions as would prevent our enemy from getting at us. But this would excite the derision of the world, would not be worthy of a brave people, and would also prevent our own ships from having access to the ocean, and thus destroy our own commerce, one of the first objects the enemy himself would desire.

Some advocate reliance upon torpedoes alone, but they forget that it is as easy to take up torpedoes as to put them down unless they are under fire. Torpedoes do very well in their place and are a necessary adjunct to the defensive arrangements of the present day, but they cannot be depended on unless supplemented by something else. This something else is guns of respectable size.

The next question that arises is, shall these guns be mounted in forts or in ships? Some think forts unnecessary and ships all that is needed.

To depend on the navy alone would require that at every point to be defended we should have at least as strong a fleet as an enemy could be expected to bring against us, as we could never tell at what point he would appear. If our defence at one point were successful, the enemy could promptly go somewhere else, and we must still remain in our first position lest he return. If our defence at any point failed, we would lose not only our ships which were stationed there, but also the place we had attempted to defend. With such a coast as we have we could never expect to provide ships enough to defend it thoroughly. The first cost of mounting guns ashore is far less than putting them on ships, and the life of ships is short; whereas forts of masonry and sand may last for any desired time.

It would take a navy greater than that of all the other nations of the world combined to defend the immense coast line of the United States. We can never expect to have a navy one-twentieth as large as that. And it would not seem fair or right, even if we had such a navy, to tie it down to the purposes of coast defence, when its power of mobility enables it to take the more imposing duty of going after the enemy, fighting him where he is to be found and compelling him to keep near his own possessions for their defence.

As far back as 1816 the Board of Engineers laid down the following principles for the defences of our coast:

First.—They must close all important harbors against an enemy and secure them to our military and commercial marine.

Second.—They must deprive an enemy of all strong positions where, protected by naval superiority, he might fix permanent quarters in our territory, maintain himself during the war, and keep the whole frontier in perpetual alarm.

Third.—They must cover the great cities from attack.

Fourth.—They must prevent, as far as practicable, the great avenues of interior navigation from being blockaded at their entrance into the ocean.

Fifth.—They must cover the coastwise and interior navigation by closing the harbors and the several inlets from the sea which intersect the lines of communication, and thereby further aid the navy in protecting the navigation of the country.

Sixth.—They must protect the great naval establishments.

These principles are fundamental and have stood the test of argument and experience. While principles do not change, the means of carrying them out do. A half century ago use was made mainly of masonry walls in our country as in others. And the idea had very obvious advantages; but these walls do not satisfy present conditions as a main dependence, although, as stated above, there are many positions in which they are still useful and valuable.

The works arranged for the defence of important points should be so located that the enemy cannot come within range of the objects to be protected without subjecting himself to a heavy fire. The best points for the defensive works are at narrow parts of the channel of approach, or where the channel comes near the shore. The armaments should be at least equal in weight of metal to those of any possible attacking fleet, and the torpedo defence should be so complete that no ships could attempt to cross the lines without danger of destruction.

The very great range of the modern rifled gun is a decided advantage for the navy, as it enables a hostile fleet to throw shot and shells into a large object, like a city, from a very long distance. This makes it necessary for the defence to occupy lines much more extensive and much farther than formerly from the object to be defended. On the other hand, while this very great range may not be of much value in

firing at an object so small as a single ship so far distant as to be invisible or nearly so, the great power and accuracy of the rifled gun make it extremely dangerous for a ship to come within range of the shore batteries, even if she be covered with the heaviest armor.

The true, and grand, and inspiring function of the navy is to protect abroad and on the high seas our rights and our commerce, to extend the weight of our arms to the enemy's own shores, and to keep his fleets so busy in acting on the defensive as to disable them from blockading or attacking our ports.

General Abbot, the President of the existing Board of Engineers, has, in a recent magazine article, succinctly stated his conclusions on the subject, as follows:

"In fine, our true policy for coast defence is to fortify the chief ports along our coasts, so as not only to protect the adjacent cities and arsenals against insult, but also to provide safe refuges for our coastwise marine, and safe naval bases with coaling stations, depots of supply, and places of refuge for our ships of war when threatened by superior forces on the ocean, whence they may issue to act offensively as circumstances permit. This would render any attempt to blockade a wide expanse of coast impracticable, and would leave our ships of war free to operate on the lines of supply of the enemy if he should attempt to concentrate and attack any particular port."

The use of large rifled mortars enters more extensively into the American system of fortification than of any other nation as yet. By this means iron-clad ships are assailed in their most vulnerable part, their unarmored decks. With a mortar having a calibre of 12 ins., enough weight of projectile is obtained to insure penetration of the decks, and the shells have size enough for large charges of high explosives. The mortars may be mounted at comparatively small expense, so that their number can be greatly increased and to an extent more than sufficient to over-weigh their smaller accuracy of fire. In this last particular, however, the modern mortar is greatly in advance of its predecessors. These mortar batteries can be readily located in low and retired positions, so as to be out of sight of an enemy and thus much less liable to injury from his fire.

The coast defences of Charleston successfully withstood the naval attack of Sir Peter Parker in 1776. They again withstood the naval attacks of 1861–65.

The naval attack of Admiral Cockburn upon Baltimore failed in

the war of 1812. Washington would not have been captured and burned in the same war if the approaches to the city by the Potomac and Patuxent rivers had been properly defended against ships.

In the civil war Fort Fisher, on the Cape Fear River, yielded only to a combined attack of the land and naval forces.

Our defensive works have been arranged in classes according to the relative importance of the places to be defended. For years nothing was done by the United States on fortifications or for the Navy. There has been a considerable revival in these matters in the past few years, but we are still much behind European nations. In this period of inactivity on our part other nations have spent large amounts of money in most expensive experiments with guns and armor. We have profited by their experience. The eyes of our officers, both of the Army and Navy, have followed these experiments with eager attention and we have thus gained much knowledge without much expense to ourselves. The reasonable limit of size of guns and the dimensions of armor plates seems to have been reached; we have now excellent factories of our own for turning out both guns and armor, and we can now go forward in making them. The gun factory at Watervliet is not surpassed in its capacity and arrangements, which take in all the latest improvements. The same may be said of the navy factory at Washington.

The magnificent works at Bethlehem are most complete in their appointments, and we have other admirable private factories, even if one of them has turned out a lot of bad plates. The Pacific coast should have a factory of its own for producing the heaviest guns and carriages.

There is another most important element in our defensive system which deserves extensive development, and fortunately public attention seems to be turning very much in that direction. I refer to the Ship Canal.

Our Atlantic and Gulf coast is so very long that the interior line of water-way parallel to it, which could be made so easily, is of very great importance. Its advantages are great from the commercial point of view in time of peace, and in time of war with a great maritime power its usefulness to our naval and merchant marine would be incalculable.

The interior water route parallel to the Atlantic and Gulf coasts

would enable the navy to pass rapidly and freely from point to point even if the coast were blockaded, and thus, as it were, multiply itself.

Take, for instance, the advantages of a ship canal connecting the great bays of the Chesapeake and the Delaware. It would enable a single fleet to be prepared to promptly meet an enemy threatening either of these bays, and, while waiting for his plans to develop, it could remain in a secure harbor in the canal, from which it could readily emerge in either direction when necessary.

The recent experiment made by the torpedo boat *Cushing* in passing by the inland route from Washington to New York is very interesting. South of Washington, Nature herself makes the way for its easy continuance at small cost.

A very interesting description has lately been sent to me by Mr. Marshall Parks, of Norfolk, Va., of a voyage of a little steamboat called the *Germ* more than 50 years ago from Norfolk up Chesapeake Bay, through the canals to the Delaware and Hudson rivers, up the Hudson, into the Erie Canal as far as Syracuse, up to Oswego and out upon Lake Ontario. This little boat, the *Germ*, was 50 ft. long, 8 ft. beam, with a draft of 3 ft.

The voyage of the *Cushing* has shown that, even with our present canals and interior water-ways, torpedo boats could be concentrated at any point of attack without going out to sea, and, of course, be free from molestation from the ships of the enemy. But the widening and deepening of these inside passage-ways to an extent sufficient to carry our new cruisers and iron-clads to any city that might be threatened with attack is a matter still more important.

For the Chesapeake and Delaware Canal very elaborate surveys were made in years past under my supervision, and full information presented to Congress, but nothing has yet been done. It is a question which, in a commercial sense, interests western shippers by offering a shorter, cheaper and less dangerous route to Europe, and also those engaged in coastwise commerce; while to the Army and Navy, by giving unimpeded movements to fleets, to troops and munitions of war, such interior ways would present advantages that have long been recognized by both naval and military men.

The people of Philadelphia are also fully alive to the importance of the inland canal between that city and New York. In time of war it would enable the Government to move its fleets from the mouth of

the Delaware to New York in perfect safety. Then, if the Chesapeake and Delaware Canal were also made into a ship route, Norfolk, Washington and New York would be in close communication with one another. If the water front should be beleaguered by an enemy, this inside line would become almost invaluable. As for merchant vessels, there would be no storms for them to encounter, no possibilities of shipwreck. They would be in land-locked waters all the time.

England works assiduously at her water line from the mouth of the St. Lawrence to the interior of her immense North American possessions, and we can find no fault with her for that, but we should not be outstripped by her in that quarter. We should also have a great canal to connect the lakes with the Mississippi. A very important link in our interior system is also the great canal which begins near us at Buffalo, but it should be made deeper and otherwise improved.

But most important of all to us is a trans-isthmian canal under our own control, to shorten the distance by water from our Atlantic and Gulf coasts to the Pacific. This is no new idea. As far back as 350 years, or soon after the discovery of America, although the Spaniards had an established communication across the isthmus, an easier passage-way was demanded and the project was conceived of constructing an artificial water-way by one of the three routes, Tehuantepec, Nicaragua or Panama, whose relative advantages have been diligently discussed at intervals ever since.

A most important step forward was made in this matter when President Grant appointed a commission in 1872, consisting of several able men, to consider the subject of communication by water between the Atlantic and Pacific oceans. After careful study this commission reported in favor of the Nicaragua route, and nothing has occurred to show that they were not right in their conclusions.

President Hayes, in 1880, presented the subject tersely and forcibly in the following words:

"An interoceanic canal across the American isthmus will essentially change the geographical relations between the Atlantic and Pacific coasts of the United States, and between the United States and the rest of the world. It will be the great ocean thoroughfare between our Atlantic and Pacific shores, and virtually a part of the coast line of the United States. Our merely commercial interest in it is greater than that of all other countries, while its relations to our power and prosperity as a nation, to our means of defence, our unity, peace and safety, are matters of paramount concern to the people of the United States."

A recent writer uses the following strong language:

"But besides the great strategic advantage of the canal, there would be many smaller military advantages given to the United States by the water-way, if, during times of war, it is maintained under the control of the Government. Such, for instance, would be the transport of very heavy ordnance, or torpedoes and bulky material, and of military stores and ammunition from the great manufactories of the East, when the difference of time between sea and land transit would not be important, or when the transcontinental railways are working to their limits. In addition, torpedo boats and other small craft; monitors, perhaps, or improvised ships; and possibly very heavy coast-defence vessels with small coal capacity, might pass from ocean to ocean through the canal when it would be impracticable to send them around South America. And, lastly, the armed forces of the United States might be transported from the Atlantic or Gulf to the Pacific without the aid of the railroads in certain contingencies too remote to make it worth while to discuss them here. Such will be some of the advantages of the Nicaragua Canal to the defence.

"But it often happens that the best defence is the attack, and from this point of view a canal will be of exceeding value to the United States. Not only will it permit the speedy passage of troopships to those countries which have in recent years several times shown their hostility to our flag, but it will bring within our reach the merchant shipping of Europe which reaps such a rich harvest along the coast of South America from Chili to Panama, and will enable us to strike great commercial interests like those of the nitrate beds, as well as to reach the war ships and land defences of a western South American State.

"With a power to throw a preponderating force on either seaboard, it is evident that the United States may not only defend her own coasts effectively, but may be enabled to so concentrate her naval strength as to threaten any point north or south on the coast of either ocean or in the West Indies, without weakening too greatly her own coast protection, and thus divert a large force of hostile ships by the necessity of defending such stations as Halifax, Esquimault, Bermuda, Havana or Jamaica; and of guarding merchant shipping in western waters.

"Of course, a canal under American control will divert part of our strength for its defence, but considering the position of the water-way, forming, as it will virtually, a portion of our own coast line, this amounts simply to adding one more port to those already existing on each of the Atlantic and Pacific coasts. Such ports should strengthen rather than weaken the naval defence, since both may be converted by land works into strong harbors of refuge and naval bases, or coaling stations which we greatly need."

It may be considered as certain that the Nicaragua Canal will be

opened before many years have rolled by. If it be not done by the United States, it will be by England or Germany. Let us hope that our legislators will not permit such a thing to happen to us as its control by a foreign power.

It is not unlikely the overland railroads prefer that this water-way be not opened, under the misapprehension that it would injure their traffic, yet everyone who has made a study of the general subject, already ably presented by many, feels assured that the construction of the canal would build up all of our overland railroad interests by developing productions that cannot now have a profitable market, as the railroads cannot afford to carry such bulky and heavy freight at a living rate to the producer.

I will not dwell longer on this highly important feature of our system of national defence, but I take pleasure in calling attention to a most interesting paper concerning it recently printed by Congress. It is from the pen of Captain George P. Scriven, of the Army, and worthy of careful perusal.

I do not claim to be a prophet, but the day seems to me not very distant when the United States will construct and own and hold a ship canal by the Nicaragua route. Then, perhaps, we will extend our domain as far down as that canal and make it a part of our southern coast line. Next, we will absorb Cuba, and then our cup will be sufficiently full.

We have been passing through a period of great commercial and financial depression. But the pendulum never swings continually in the same direction; the reaction will soon come. A revival in business activity will take place; its strides will be rapid and large. Let us hope that a part of it will be the prompt and energetic commencement and completion of the Nicaragua Canal as the work and the property of the United States. The future will surely bring ridicule upon the United States if any other power be permitted to control the Nicaragua Canal.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

TRANSACTIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

711.

(Vol. XXXI.—June, 1894.)

A CONCRETE SEWER ON PILES.

By EUGÈNE LENTILHON, Jun. Am. Soc. C. E.

READ JUNE 6TH, 1894.

WITH DISCUSSION.

The work described in this paper consisted in the building by the Dock Department, at the foot of Canal Street, North River, New York City, of about 180 ft. of concrete sewer, 16 ft. wide by 7 ft. deep, on a foundation of piles and grillages (Plate LXXIX), with overflow chambers (Plate LXXX) resting on a foundation of piles capped with 12 x 12-in. timbers, and decked. The overflow chambers are designed to carry the storm water and sewage during very high tides. The sewer drains an area of 366 acres, and was originally carried out from the westerly line of West Street in a wooden structure on a crib foundation.

The method of construction from the section *E F* (Plate LXXIX) to the connection inshore with the Department of Public Works sewer was the same as that shown at *E F*. The work was done under the direct supervision of the writer, and in preparing this paper care has been taken to determine accurately the actual cost of construction of each class of work as it progressed, thereby enabling readers to

compare the classified items of construction, with the difficulties encountered and hereinafter described.

The location of the work was such that it was impossible to use any but floating derricks and machines in its construction, and all the concrete, mortar and grout used had to be made in mixing boxes on deck scows, and carried in wheelbarrows along narrow runs from the scows to the work. The oscillation of the scows, due to wind and the swells from passing tugs and steamboats, necessarily made progress slow, and often dangerous, as the runs were about 25 ft. long and from 4 to 8 ft. above the surface of the water. The narrowness of the slip—102 ft.—was a great drawback to the work, as frequently three deck scows 30 x 70 ft., derricks from 30 x 70 ft. to 60 x 70 ft., and a pile-driver 23 x 45 ft., were in use at the same time.

The reason for establishing so low a grade for the bottom of the sewer was that the Dock Department work had to connect with the grades of the Department of Public Works at the westerly line of West Street. The piles were driven by means of a floating pile-driver, the hammer weighing 3 400 lbs., with the exception of about 50 piles driven by a land machine near the westerly line of West Street, where there was not a sufficient depth of water for a floating machine. Cast-iron pile shoes were tried in driving through the cribs of the old sewer foundations, but did not prove successful, and consequently were abandoned. The cost of labor per pile for driving the foundation and test piles, including the rigging of a batter-ways and the land machine, was $3 91, and the actual number of days employed in driving was 65. The prices of the piles follow:

Length of Pile.	Diameter of Pile at Butt.	Diameter of Pile at Point.	Price per Pile.
Feet.	Inches.	Inches.	
40 to 45	12	6	$4 99
45 to 50	15	6	6 85
50 to 55	15	6	8 00
60 to 65	14	7	7 50
60 to 65	14	7	9 50
80 to 85	14	7	10 00

The average cost per pile was $6 07, and over 63% of them were 40 to 45 ft. long.

Several methods of cutting off the piles accurately and economically, for the reception of the grillages at an elevation 1 ft. below

the Dock Department mean low water datum, were tried, and the following method was used and proved successful, the work progressing rapidly and accurately at a minimum cost, without the necessity of waiting for low tides.

A point about mean high water was located on each pile, and as soon as the tide had ebbed to + 1.0, dock-builders got into the water and sewage, frequently being submerged to their necks, and sitting or kneeling on braces temporarily located the day before, measured down with a rod of given length from the point located on the pile, and fastened two small battens on the opposite sides of the pile, to guide the saw. Frequently two men, with a good low tide, have sawn off three piles. Elevations taken on the piles after cutting showed no greater variation than 0.04 ft. Elevations taken on the grillages at numerous points showed a variation from — 0.25 to — 0.33, which could easily be accounted for in the milling of the timber used in their construction. The cost of sawing by this method was $1 28 per pile.

In cutting off the piles for the large foundation blocks at 15.29 ft. below mean low water, a 3-ft. 6-in. circular saw fastened to a shaft temporarily suspended in the ways of a pile-driver, with the necessary belting leading to the engine, etc., was used. These piles, after being sawed off, were located by divers.

The grillage was built in four sections, on a pier adjacent to the work, launched and floated in place at high water and left to ground at low water when possible. This could only be done in the case of the two easterly sections, as an embankment of earth north of the grillage kept washing in over the tops of the piles at each high water; and the flow of the sewer at points west of this was not strong enough to carry away large deposits of sewage, so every pile in this area had to be swept clean before the section could be landed in place. To do this, tides sufficiently low to clean the piles sawed off at a grade of 1.0 ft. below mean low water were necessary, thus causing delay, as the dates of location of the different sections, October 3d, 7th and 25th, 1892, and April 18th, 1893, show. The delay in fastening the last section in place was caused by an unusually severe winter, which prevented the obtaining of cobble stone to place between the piles at the westerly end of the foundation. The cobble stone used in filling up the spaces between the piles was of various sizes, from 6 ins. in greatest dimension down to coarse gravel, and was obtained from a cobble bank

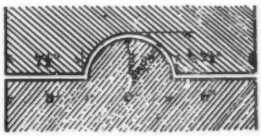
at Cauldwells on the Hudson River, about 45 miles from New York. The scows loaded with this material could not be towed to the work, as the Hudson was closed by ice, and this part of the work was in consequence delayed until the opening of navigation in the spring of 1893. The price of cobble per cubic yard placed in the foundation was 65 cents.

The ten special concrete foundation blocks, of which the five sub-blocks averaged about 63 tons in weight and the five top blocks averaged about 70 tons, set in place by the 100-ton derrick *City of New York*, also caused considerable delay, as the cold weather would not permit the mixing of mortar for the mattresses at the time the pile foundation was ready to receive them. The mattress is used to take up any unevenness in the low-grade piles, and consists of mortar made of slow-setting Portland cement and clean, sharp sand in the proportions of 2½ to 3, the sand screened to ¼ in. largest dimension, placed in bagging sheets and lowered into place by means of a frame swung from the derrick and placed with the assistance of divers. Great inconvenience and some delay was also caused by the narrowness of the slip in setting the blocks. The derrick *City of New York*, 60 x 70 ft., lying alongside of a deck scow, 30 x 70 ft., which carried the concrete blocks, left very little margin for manœuvring the derrick into place after the base block was lifted clear of the deck of the scow.

In all concrete work, broken stone not larger than 2 ins. in diameter, fine sharp sand and Portland cement not less than 400 lbs. gross to the barrel, subject to the Department of Docks' specifications, were used and mixed in the following quantities, called a batch: one barrel of cement, two barrels of sand, and five barrels of broken stone. A batch averages 2 600 lbs. in weight and contains 0.61 cu. yd. The 71 sewer-wall blocks, weighing from 4 to 9½ tons, were transferred from deck scows to the grillage, by 10 or 12-ton floating derricks, as soon as the different sections were finished or the capping decked, and on 3-in. rollers, were rolled into place by hand, with the aid of crowbars, and a 4 × 10-in. yellow pine lever, 15 ft. long. Great delay was occasioned here also, as the deposits from the sewer during flood tide frequently amounted to 4 ins. in depth, and to give a perfect bearing for the sewer-wall blocks by adzing off of any unevenness of the grillage, it was necessary to wait until the tide had receded to — 0.33.

Several weeks frequently elapsed on this account between the setting in place of two adjacent wall blocks.

The sewer walls were made continuous by tongue and groove joints, grouted, as shown in the accompanying sketch of the top of a side-wall block.



The cost of landing, handling and locating the 71 sewer-wall and overflow chamber blocks was $19 39 per block. This work was done by dock-builders.

The concrete blocks were built at the East Seventeenth Street Department Yard in wooden moulds, especially erected for the purpose. The cost of concrete per cubic yard in the 10 special foundation blocks, the 71 sewer-wall blocks, and that placed between the I beams, follows :

Class of work.	Cubic yards in place.	Cost per cubic yard for labor.	Cost per cubic yard for material.	Total cost per cubic yard.
10 special foundation blocks.....	234	$4 51	$7 39	$11 90
71 sewer-wall blocks.....	291	5 26	5 94	11 20
Concrete between I beams	212	3 14	5 00	8 14

The beams were telegraphed in place by a floating derrick, located near the established bulkhead line. The telegraph is a primitive but useful method to transfer heavy loads used in dock-building, and consists of a double-drum hoisting engine, a mast or pile-driver ways, some lines, and a snatch block. A heavy line, in this case 5 ins., fastened to some distant point about on a level with the deck of the pile-driver or derrick, as the case may be, is run over a sheave at the top of the pile-driver ways or derrick mast and led to the engine drum. A snatch block is then hung on this line between the points of support, to which the load is fastened with a smaller line, in this case 3½ ins., leading over another sheave next to the first one, then to the second drum of the engine and the telegraph is ready for use. The pile-driver or derrick being anchored, heavy loads can be moved with ease by raising and lowering one or both of these lines.

It was at first intended to place the blue stone on the grillage and decking in a 1-in. bed of mortar (see plates), but tides sufficiently

low to enable the placing of mortar on the grillage when bare were so few and far between that after considerable delay and several vain attempts to have the mortar set in the greasy water issuing from the sewer, it was decided to set the blue stone in place, smooth side down, without mortar.

The cost of building the sewer, its overflow chambers and outlets follows, with the exception of the items of dredging, cobble and rip-rap, piling, etc., and the labor and material accompanying the setting of the base blocks under the oval sewer outlets north of the line marked "present line of concrete blocks" (Plate LXXX).

Cost of making temporary outlet to sewer	$1 041 37
" Piles	3 103 37
" Driving piles, stay-lathing, etc	2 145 03
" Sawing piles off by hand	660 02
" Making and fastening grillages	1 145 63
" 75 787, B. M., ft. of yellow pine timber	1 600 47
" Capping	195 36
" Tree nails and wedges	205 67
" Seventy-one sewer-wall blocks (labor and material)	3 261 14
" Handling and setting sewer-wall blocks	1 377 31
" Bluestone	937 59
" Inspecting, handling and setting bluestone	818 39
" I beams	3 118 66
" Inspecting, placing and painting I beams	1 205 38
" Placing concrete between I beams	665 11
" Ten special foundation blocks (labor and material)	2 647 14
" Cutting and setting granite in five top base blocks	1 251 14
" Setting 10 special foundation blocks	588 72
" Cobble and rip-rap	537 90
" Divers' suits, rubber boots, coal oil, etc	702 88
" Cement, sand, and broken stone	938 21
" Towing scows, rafts, derricks, etc	751 91
" Loading scows with concrete material	167 37
" Excavating for grillage, cutting away old crib, etc	581 48
" Making centers (labor and material)	282 27
" Moving scows and rafting timber	435 44
" Inspecting cobble and rip-rap and laying deck	216 90
" Cutting granite for sewer outlets	84 66
" Watching	1 346 85
Total	$32 013 37

In explanation of the cost of the items for towing, loading scows, rafting timber, and watching, the writer would say that all of the material used, sand, broken stone and cement, was loaded on scows at the West Fifty-seventh Street Department Yard, with the exception of the blocks built at the East Seventeenth Street Yard. All of the sawed timber used was drawn from the West Seventy-fifth Street Department Basin, necessitating, with the transferring of derricks and other floating property, a large amount of towing. As watchmen were required on all floating property, the item for watching will not appear excessive, for watchmen were frequently required at several different places at the same time, to care for the material and property being used for the construction of the sewer.

The engineers, surveyors and draughtsmen's time, and interest on the plant, are not computed in the cost of construction.

The Dock Department rates of labor are as follows:

Occupation.	Rate per Hour.	Rate per Day.	No. of Hours in Day.
Laborer	$0 23	$2 30	10
Foreman of laborers	0.35	3 50	10
Dock-builder	0.30	3 00	10
Foreman of dock-builders	0.35 to 0.45	3 50 to 4 50	10
Engine-man	0.35	3 68	10½
Watchman	0.16⅔	2 00	12
Saw-filer	0.35	3 50	10
Diver	1.00	5 00	4
Diver's tender	0.35	3 50	10
Stonecutter	0.50	4 00	8
Stonemason	0.50	5 00	10

In addition to the above sewer, the standard bulkhead-wall was projected about 35 ft. south of the special sewer outlet base blocks, and a standard department pier 724 ft. long by 40 ft. wide, was built by contract, and carries the sewer out to the pier head line in two oval-shaped creosoted stave barrels 4 ft. 3 ins. x 5 ft. 10 ins. in diameter; 2 760 sq. yds. of granite paving, with the necessary drains and receiving basins, was laid on a 3-in. bed of sand, with coal tar and gravel joints over the area reclaimed, by filling in east of the established bulkhead wall, and a dump, 275 ft. 8 ins. long by 17 ft. wide, was built on the southerly side of the pier, all at an additional expense of about $90 000.

DISCUSSION.

CHARLES MACDONALD, Vice-President Am. Soc. C. E.—I would like to ask Mr. Lentilhon why cast-iron shoes were not successful?

Mr. LENTILHON.—A certain number of pile shoes were ordered and used. I found in some of the work, after we had sawed off the piles for the sewer and got down in the mud around the tops of those along the northerly side of the wall, some of the shoes bent double. In many instances where we had to drive through rip-rap, we used this same sort of shoe with great success.

Mr. MACDONALD.—I understand it is not your opinion that the cast-iron shoes were necessarily unsuccessful in such work?

Mr. LENTILHON.—It is not my opinion; they were not really abandoned.

Mr. MACDONALD.—I notice in the table, on page 573, you give the cost per cubic yard of material for special foundation blocks as $7 39, and in the concrete for the eye-beams as $5; what was the reason of that difference?

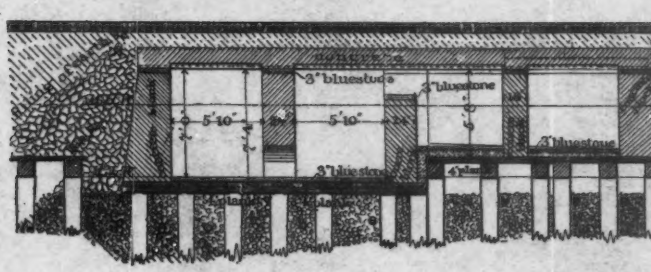
Mr. LENTILHON.—That can be accounted for by the fact that entirely separate molds of peculiar shape had to be built for those blocks; whereas, for the concrete put in the eye-beams there were no molds at all except the planks at the north and south side of the beams. We picked up any old plank we could find for that.

Mr. MACDONALD.—Is not even $5 a rather excessive charge for materials—for concrete? Was there any reason why your material should have cost $5?

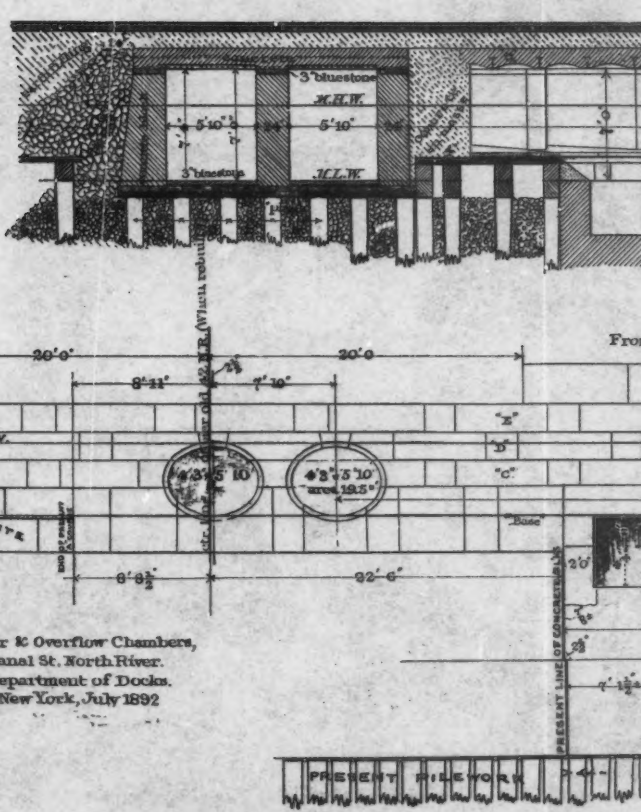
Mr. LENTILHON.—At that time, I believe, the cost of Portland cement was $2 04 to $2 20 a barrel; it averaged about $2 14. The same cement to-day is only costing $1 80. It took one barrel of cement, with the broken stone and sand, to make $\frac{4}{5}$ cu. yd. of cement. It may be interesting to state here, in connection with the ten special foundation blocks which cost $11 90 a cubic yard, that the records of the Dock Department show that between 1890 and 1893, 329 such blocks in all were made, and if we take an average weight of about 65 tons per block, it would make 21 385 tons, of which the average cost was $9 59 a cubic yard.

A. A. STUART, M. Am. Soc. C. E.—I desire to ask the author why concrete was used in building those walls in lieu of stone masonry. As I understand the figures given in the paper, the blocks used in the walls cost about $12 per cubic yard, exclusive of setting, and if this understanding is correct, it would seem that concrete was used because of its supposed greater durability than good ashlar masonry, which in most localities can, in similar situations, be built for no greater cost than that given as the cost of this concrete. My under-

Section on C-D,

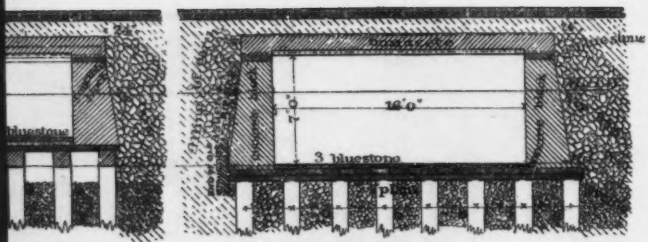


Section on A-B,

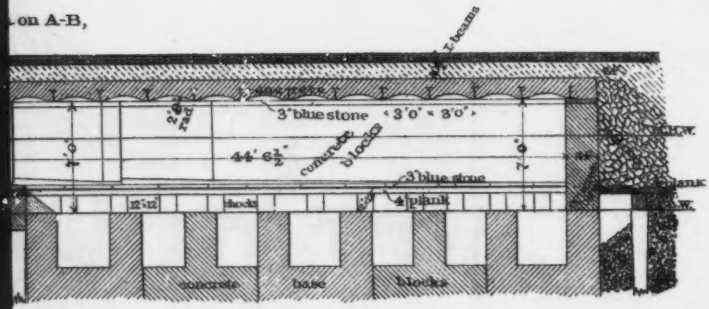


Sewer & Overflow Chambers,
at Canal St. North River.
Department of Docks.
New York, July 1892

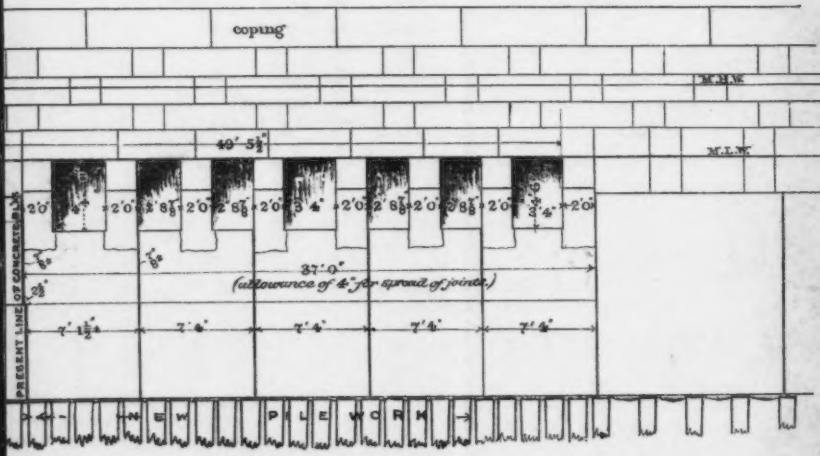
Section on E-F.



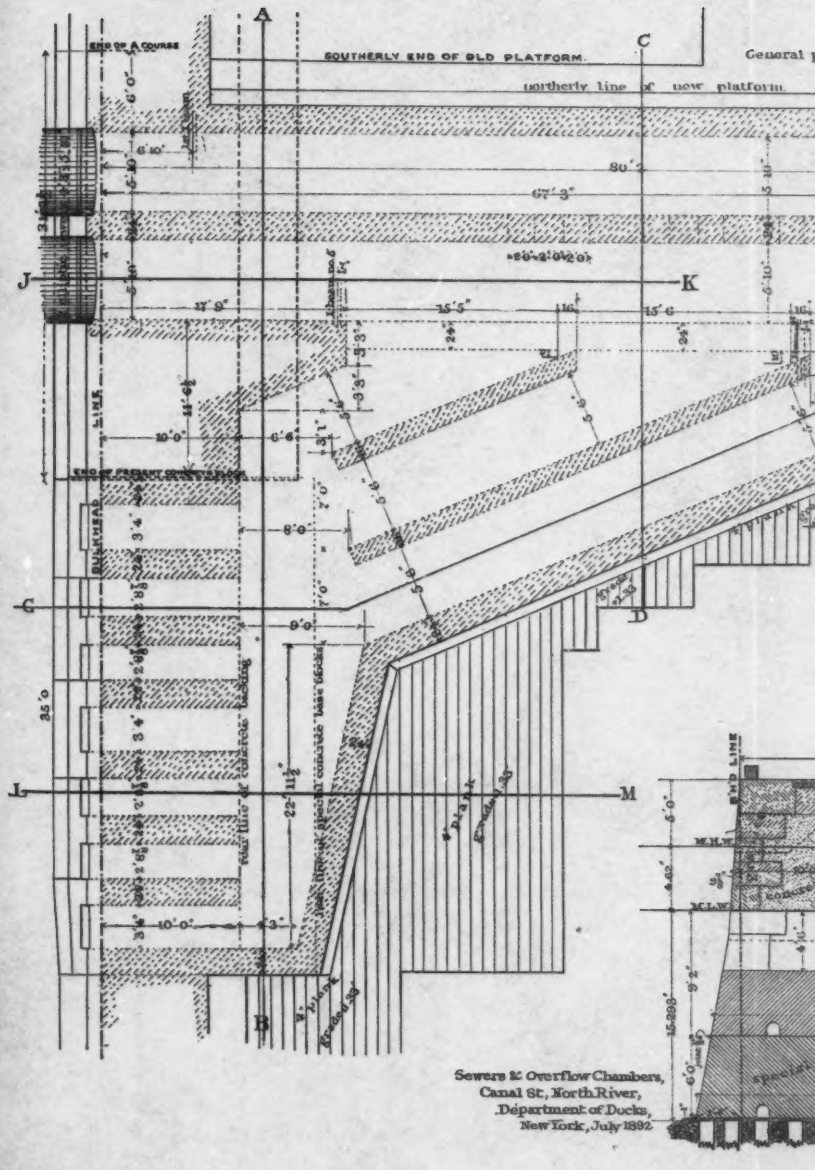
on A-B,



Front Elevation of Bulkhead Wall, showing sewer & overflow openings.

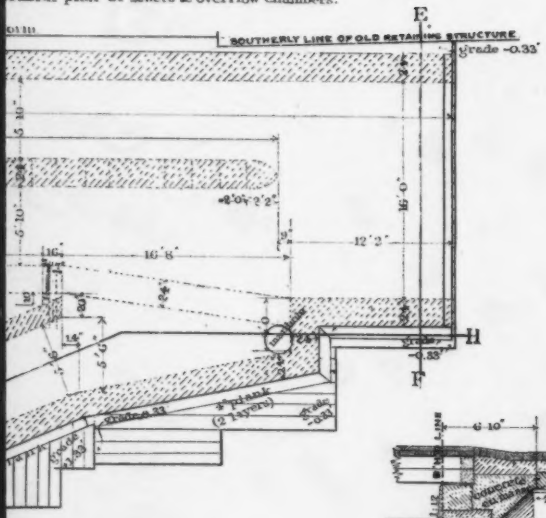


NGRS.
.
E SEWER.

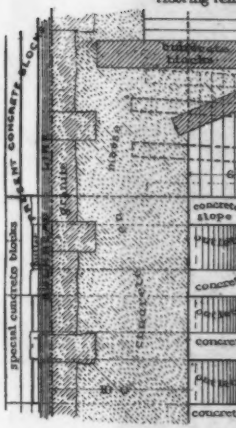

A
B
C
D
J
K
L
M
SOUTHERLY END OF OLD PLATFORM.
northerly line of new platform
END OF A COURSE
BULKHEAD LINE
END OF PRESENT CONCRETE
Rear line of coping
Face line of coping
Sewers & Overflow Chambers,
Canal St., North River,
Department of Docks,
New York, July 1892

LEN

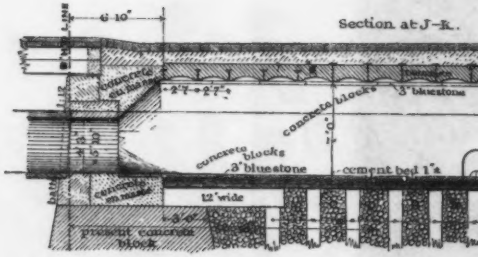
eneral plan of sewers & overflow chambers.



Plan of po
flooring rem



Section at J-K.



Section at G-H.

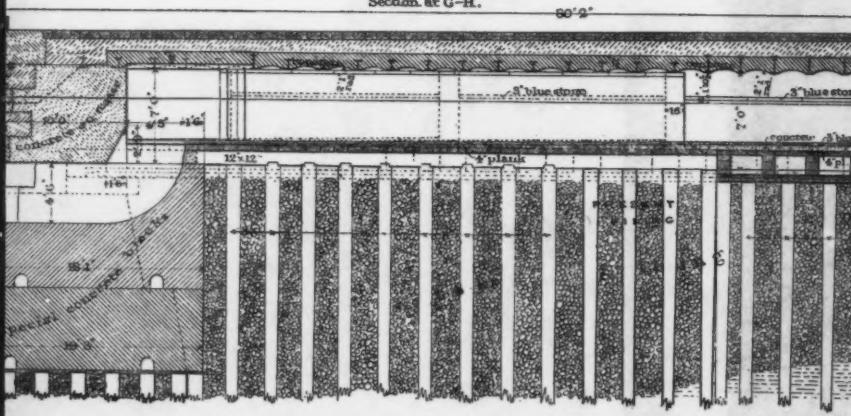
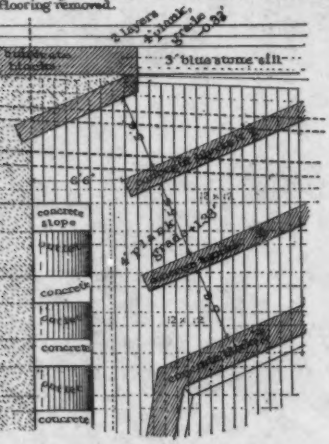
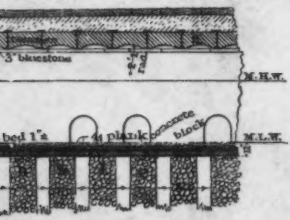


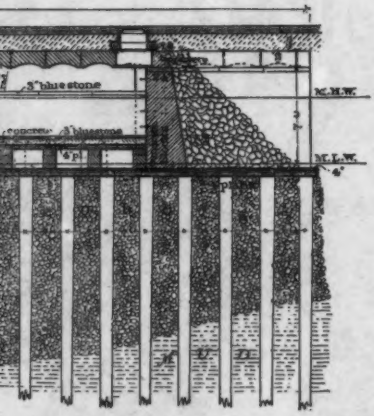
PLATE LXXX.
TRANS. AM. SOC. CIV. ENGRS.
VOL. XXXI, No. 711.
LENTILHON ON CONCRETE SEWER.

Plan of portion of outlet chamber with bluestone flooring removed.



at J-K.





standing has been that concrete is used in building sea walls and similarly exposed structures, because of the fact that it can be made into larger individual blocks than can be procured from the average quarry at moderate cost, but as the blocks used in this work were not beyond the range of most quarries to furnish at reasonable cost, it appears that considerations other than that of economy must have suggested the use of concrete. If it is thought to be more durable than good masonry, the statement of that fact would be an interesting one to have brought out.

Mr. LENTILHON.—I would say that opens up a very interesting subject for discussion which I am not here to discuss or criticise. That is Mr. Greene's bulkhead wall; it has proved a success.

Mr. MACDONALD.—Gentlemen who are familiar with the bulkhead wall will remember that it was necessary to place large masses in position, and the only convenient and inexpensive way in which to obtain monoliths of this size was by forming them in molds in concrete. That was determined upon early in the construction of the dock wall. I am sorry that Mr. Greene himself is not here; he could, perhaps, enlighten us. I recollect hearing the matter discussed when General McClellan was Chief Engineer of the Dock Department and Mr. Van Buren was his principal assistant.

WM. BARCLAY PARSONS, M. Am. Soc. C. E. (by letter).—The paper by Mr. Eugene Lentilhon has the merit, in addition to being interesting, of setting forth in detail the cost of the work. But it is not quite clear why there is the great difference in the cost of concrete in the foundation and wall blocks and that placed between the I beams, where the cost of the materials varies from $5 to $7 39 per cubic yard, although he states that the mixture was the same in all cases. Neither is it clear why the labor for the concrete between the beams is so very much less than the cost of the labor for the concrete in the blocks, since, in the first place, the amount of concrete was small; whereas, in the other case it was used in large masses, and therefore should have been much more cheaply handled. The total cost of the concrete per cubic yard in foundation and wall blocks seems very high, especially as these blocks were very large, thus giving an opportunity for cheap work per cubic yard. According to the paper, the item $11 39 is the cost of the concrete blocks in the moulds, because there is a separate item for handling and setting the same.

The total cost of building 180 ft. of sewer may seem very high, but it must be remembered that it was built through very bad ground, and was built according to the New York Dock Department standards, where excellence of workmanship and material are the first considerations. The care with which the work is done is shown in the small item of watching, which amounts in this case to over 4% of the whole, a percentage usually enough to cover the expenses of engineering;

whereas, in this case, the watching applies solely to the day and night men employed to take care of the plant and material.

Mr. LENTILHON.—The point of the difference in cost between the concrete put between the I-beams and that in the moulds has already been brought up. The reason for the cost per cubic yard being greater is, that in making the concrete in the first case, laborers at 23 cents an hour were employed. In making the concrete in blocks, in addition to the laborers actually employed in mixing the concrete, it takes carpenters and expert mechanics, who received 39 cents an hour, to make the moulds, which cost is figured in the cost per cubic yard of concrete.

In making five special foundation blocks there were two molds of one kind and three of another. The reason for giving an average for so many wall blocks, covering the period between 1890 and 1893, was to illustrate the difference in price of materials, labor, etc., as used in the wall and that in the sewer. In that period there were probably not more than half a dozen molds made—there might have been more; and they were used until they wore out. The difference in cost between the standard wall blocks and the sewer-wall blocks was about $2 a yard.

Mr. MACDONALD.—Is there anything, in your judgment, that would prevent doing work of that kind by contract, under carefully drawn specifications? I ask, because the law, as I understand it, has now been amended so that all work in the Dock Department must be done by contract. In your experience did you form any opinion as to whether it would be practicable to insure good work by contract under such circumstances?

Mr. LENTILHON.—Yes, sir; particularly in concrete work, the foremen that have been with us for years have to be urged up to their work all the time. For various reasons we have to keep shoving our men around, particularly in ramming the concrete wall-backing in low-water work; the foremen frequently fill in the concrete too hastily and try to do too much work in one day for a record. If we had Italian laborers doing the work, with contractors, I have my doubts whether the work would be done as well as now.

Mr. MACDONALD.—It is a question that the taxpayers of New York are especially interested in, not only the Dock Department, but the Park Department and the other branches of construction, as to whether work can be done by the day enough better than it can be done by contract, under carefully prepared specifications, to warrant the day system in preference to that by contract. The Legislature seems to think that all work should be done, in municipalities like New York, by contract. The engineers who are employed by such municipalities must make up their minds to devise some scheme of inspection whereby the wishes of the Legislature shall be carried out and good work obtained.

A MEMBER.—Why not extend the contract system to the employment of the inspectors and the supervision of the work? Let that be

done cheaper, too. If the law is good so far, why not extend it as far as it will go?

Mr. MACDONALD.—It is not a theory, but a condition that we have to consider. The fact is, the law is as I have stated it. It is a question whether engineers are going to be able to show themselves competent to conform to the law or not.

W. W. KENLY, M. Am. Soc. C. E.—Mr. Chairman, there is one question I would like to ask, whether the concrete work was done entirely by hand labor or by a concrete mixer?

Mr. LENTILHON.—I will state that the Dock Department does not employ mechanical assistance at all in their concrete work.

Mr. KENLY.—Is that a question of politics or is it a question of making it better by hand than by machinery?

Mr. LENTILHON.—I guess it combines a little of both.

E. B. GOSLING, Jun. Am. Soc. C. E.—I was connected formerly with the Department of Docks, and at that time had under advisement the putting up of a plant for mixing concrete by machinery. We found we had not spare space enough along the water front to prepare and store the number of blocks that economy would require us to make. Besides we would have been obliged to strengthen considerably the wooden bulkheads, to enable them to support safely the additional loading; consequently the plan was not adopted. I had suggested a machine with two inclined helices, which revolve in opposite directions and give a very thorough mixing of the materials. The machine is rather expensive, and was the invention of Mr. Coignet.

Mr. KENLY.—Inquiry was made as to the relative efficiency of contract work and day labor in the public works of the city. I have had a great deal of experience, in public work especially, and my experience has been there is no great difficulty in getting good work done by contract. As to whether you can get good work done just as well under the engineer as by day's work, I think that opens up a question of very serious importance to the Society. In my experience you can get just as good work by contract as by day's work. It is a question that involves the character of the engineer, and I do not see why, with a competent engineer with sufficient experience, the work cannot be done just as well. On large railroad works it is done in that way. Take the construction of the Baltimore system of water works, built for $125 000 less than the appropriation; that was a remarkable piece of work.

Mr. MACDONALD.—Which shows that the engineer had a wise conception of the problem before him in making his estimates.

Mr. KENLY.—He also had a wise conception of the interests of the tax-payers. But that is a question that I think is very vital to the interests of the profession of civil engineering. The statement was made that you cannot get as good work under contract work as under day's work. I think that is rather an impeachment of the ability and character of the engineer.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

TRANSACTIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

712.

(Vol. XXXI.—June, 1894.)

FAILURE OF A MASONRY PIER AND A ROCK FOUNDATION.

By WM. BARCLAY PARSONS, M. Am. Soc. C. E.

READ MAY 16TH, 1894.

WITH DISCUSSION.

On the line of the Central New York and Western Railroad, 15 miles east from Hornellsville, N. Y., there is an iron viaduct 700 ft. long, with a maximum height from stream to base of rail of 235 ft. This structure, the highest in the State of New York, was erected in 1883. The tallest tower has two of its legs resting on piers which stand in the bed of the stream. About five years ago these piers showed signs of failure and were encased in a jacket of concrete 12 ins. thick. Cracks, however, soon appeared in the concrete, which were stopped with cement from time to time, but always reappeared.

In the autumn of 1893, the superintendent of the road being anxious about the piers, the author was called in by the company to make an investigation. The concrete of one pier was found to be very badly cracked in several places. One crack, 4 ins. wide, extended from top to bottom, a height of 10 ft. The other pier was considerably, but not so

badly, damaged. The bottom and sides of the glen, the latter being very steep, consisted of a shale rock in alternate layers of hard and soft material, as will be seen from the photographic illustration accompanying this paper.

When the concrete coating was put on the piers it was founded on the top surface of the shale as exposed. The action of water, air and frost soon produced their well-known decomposing action, and the shale was so badly eaten out from under the concrete as to produce settlement and cracks. The author attempted to save the pier and concrete by excavating a trench in the rock around the work to be filled with concrete, and so stop further decomposition of the foundations; and then he proposed to fill all the cracks with strong cement mortar. But the jar produced by excavating the shale brought down a large piece of the concrete jacket, exposing the pier itself, which was at once seen to be in such a rotten condition as to be beyond salvation.

On removing the whole of the concrete, the pier was found as shown in Plate LXXXI. The pier originally had been built directly on the exposed top of the shale without any excavation, and the decomposition of the shale had wrecked the pier itself in the same manner as it afterwards destroyed the concrete jacket. An examination of the plate will show that previous to the putting on of the concrete an attempt had been made to take up the loss resulting from the decomposition of the shale by shoving beneath the masonry small stones and gravel. Attention is called to the pedestal stone, which was not only badly broken, but actually dished, which the photograph exhibits very distinctly. The stones composing the masonry were a poor quality of sandstone, breaking readily, and in this respect the plate fails to do justice to the badness of the masonry, because every stone was more or less cracked.

In order to support the tower during the removal of the pier, the false work, as shown in Plate LXXXII, was devised. This consisted of two small plate girders 5 ft. long and 30 ins. deep, with web plates ⅜ in. thick, which were fastened with turned bolts to the leg of the viaduct. This leg, which carried one-half of a 30-ft. and one-half of a 100-ft. span, consisted of three 12½-in. channels. The projecting ends of the plate girders rested on four 20-in. I beams, 240 lbs. per yard. These beams were 18 ft. long and were supported at their ends as shown by two cross-timbers, resting on three 30-ton hydraulic jacks at each end. Two stout cribs of old-bridge timbers were built up to receive

the jacks. The up-stream crib was made V-shaped in order to provide a breakwater for the stream in case it should rise during the progress of the work, and also to permit of inserting the blocking, so as to shorten the effective span of the supporting I beams. It was well that this was done, because the stream rose suddenly, and had there been a square crib, damage to the work would probably have resulted.

The jacks lifted the iron work clear of the old piers, when the blocking was immediately introduced, so that the beams rested on the blocks and jacks. The old pier was then readily removed. As was expected, the masonry was found to be in a very bad condition.

The large stones were but little more than a veneer for a dry center. The vertical face joints were in many cases but an inch deep, the stones being triangularly shaped with the bases outward. The masonry was easily removed with a bar and shovel.

Before putting up a new pier the shale rock was excavated to a depth of about 3 ft. and to a similar distance outside of the lines of the new pier. The new masonry was made with Leroy limestone, a very hard but durable stone. The stones were carefully cut with full joints, so that very little backing was used. The concrete mixture in the foundation consisted of 1 part of American Portland cement, 2 parts sand, and 4 parts broken stone. In laying the new masonry, the space beneath the iron being quite free of staging, the work proceeded in the ordinary manner, except as to placing the pedestal stone. It was evident it could not be set by dropping it over the top of the holding-down bolts. It was therefore put in place first and the long bolts run through it from below, the stone being held against the iron base plate. The pier was then built up to it, the coping stones having been carefully laid out so that the bolts passed through the joints. The base plate of the leg having been slightly bent, owing to the breaking of the original pedestal stone, a piece of sheet lead was inserted between it and the new stone in order to ensure an even bearing.

The cost of doing the work, all expenses included, was $1 041 92. Mr. G. R. Tuska, Jun. Am. Soc. C. E., had immediate charge of the work as Resident Engineer.

PLATE LXXXI.
TRANS. AM. SOC. CIV. ENGRS.
VOL. XXXI, No. 712.
PARSONS ON FAILURE OF ROCK FOUNDATION.

PLATE LXXXII.
TRANS. AM. SOC. CIV. ENGRS.
VOL. XXXI, No. 712.
PARSONS ON FAILURE OF ROCK FOUNDATION.

DISCUSSION.

J. Foster Flagg, M. Am. Soc. C. E.—I would like to ask Mr. Parsons if, during the erection of the new piers, the superstructure was held up in part by hydraulic jacks? I should not suppose that hydraulic jacks could be depended upon to carry such a load for any length of time without settlement, from the unavoidable leakage of the fluid which operates them. I should think that the load must have been practically all carried by the blocking.

Bernard R. Green, M. Am. Soc. C. E.—I think that the same lack of engineering advice must have existed when the concrete casing was put on the old pier only 12 ins. thick. It seems to have been a ridiculous method of protecting the old pier. I take it that the concrete was not applied merely to protect the pier from the effects of the atmosphere, but as a hooping or encasement, relying on the tensile strength of it to hold the pier together by resisting a bursting tendency. The thermal expansion and contraction of so thin a shell of concrete, exposed to the weather, would tend to crack it, through the natural action of the loose material inside. Small stones or particles of sand, etc., falling between the casing and the pier, after expansion in hot weather, would remain there as a fulcrum or chock when contraction followed. Cracks would be certain to result in such a case.

I will show on the blackboard a peculiar effect of expansion and contraction that occurred in the granolithic pavement around the Washington National Monument some years ago. The base of the structure is 55 ft. square and the granolithic pavement or apron about it, intended to catch the wash of rains running down the shaft, as well as to serve as a smooth foot walk about the monument, is 10 ft. wide. This pavement was therefore a hollow square inclosing the base of the shaft, about 8 ins. thick, and bounded by a granolithic curb. Of course, when under the heat of a Washington summer sun, expansion took place in all directions. It pushed all the corners outward diagonally, so that the pavement took the form of a slightly concave-sided square. The middle parts of the inner sides of the square remained in contact with the monument, but the corners were ½ in. off, and the cracks tapered to nothing at the middle points. Naturally when the pavement contracted again a little crack occurred squarely across it each way from each inner angle, and when it expanded again the dust and dirt accumulated in the cracks prevented closing and even operated to push the corners of the pavement still farther outward.

We all know that coping stones will not lie still on a wall. They are always moving from expansion and contraction, and unless tied together with something that will draw them up again when contrac-

tion takes place, permanent cracks and displacements must result. I think that was the cause of the cracking in the casing of the pier, and that the latter could not have amounted to much as a reinforcement.

JAMES OWEN, M. Am. Soc. C. E.—I have used concrete packing with success where I have put piers on shale. I have found that exposure to the atmosphere would have a tendency to disintegrate the shale, and I have protected them with concrete and found it efficacious. There was no weight on the concrete itself, of course. The peculiarity of some shales is that mere exposure to the atmosphere will disintegrate them while a protection with a covering of that kind will prevent further inroads in the material itself.

P. F. BRENDLINGER, M. Am. Soc. C. E.—I am glad Mr. Parsons is here; perhaps he can give us something that the paper lacks; that is, the history of the original construction. Apparently a contractor ran the work. Now that contractor was not an engineer, and for that reason, I say, and have said many times, that engineers should study and practice both engineering and contracting as much as possible. While it will not detract from the quality of the engineer, I think it will elevate the quality of the contractor. Here is a piece of work that, if the company had any regard at all for its money or for its future traffic or prosperity, should have been looked after. If a contractor knows his work is inspected, there is never such work as this going on. An old engineer said to me 20 or more years ago, "Any one can build a pier, but it takes brains to build a foundation." Make your foundation secure and it does not make so much difference —although, of course, it is essential to have it good—about your masonry, and your structure will still stand. No matter whether I had charge of 8 miles of road or 100 miles, I always made it a practice to see every foundation before work was started on the masonry. I never had but one case in my life in which masonry gave way that I had anything to do with, and this case was not a foundation, but the top of an abutment.

The abutment that I have reference to is the north abutment of the double-track bridge crossing over the Mount Carbon and Port Carbon Railroad, at Pottsville, Pa. The span is about 200 ft. The weight of the iron work alone is about 150 tons on each abutment, or 75 tons on a shoe, under each end post.

The foundation was 14 ft. 4 ins. deep, and 11 ft. thick. The masonry of the abutment, above ground, was 10 ft. wide at the surface, and 7 ft. under the bridge seat; 19 ft. high. The face of the masonry was vertical, so as to bring the abutment as near to the railroad crossed as possible, to reduce the span. The body of the masonry was built of Hummelstown brown sandstone, a very brittle stone, while the bridge seat was built of Conshohocken stone, a species of trap-rock, which is considered *par excellence* for bridge masonry, and especially bridge seats.

The bridge seat, in this case, was 5 ft. deep, 18 ins. thick.

The contractor had been paid in full for this work, the bridge was erected and the road was in the hands of the operating department. In the course of a few months I noticed that the stone on which one end post rested was slightly cracked. In a week or so the crack had become larger, and the stones of the abutment were cracked for three courses below the bridge seat. I knew the foundation must be good or else the cracks would have started at the bottom and extended upwards. The cracks did not extend below the third course from the top. So it was decided to tear out the cracked masonry. The bridge was carefully propped up by the operating department and the contractor who built the masonry tore down the cracked part and rebuilt the same with Conshohocken stone throughout (at his own expense). The cause of the cracking was held to be some under-pinning with chips, but it was an open question with me whether the brittle Hummelstown sandstone was not brought too near a 75-ton pressure, in a small area.

F. Collingwood, M. Am. Soc. C. E.—A partial failure, similar in kind to that mentioned by Mr. Brendlinger, occurred in one of the piers of the Allegheny Suspension Bridge at Pittsburg. I was called upon in 1883 to examine the bridge, and make such repairs as were needed. I found that when the suspension bridge was built, there had been a widening of the spans; and one of the piers had been enlarged by building new work at the side and ends and across the top of one of the old ones. There was a vertical crack in this pier some 10 ft. long, under one of the iron columns supporting the cables, and some of the stones at other points had cracked more or less and weathered badly.

It was not considered safe to remove more than one stone at a time. When this was done the work in the interior of the old pier was found to be full of spaces, the grouting used not having penetrated throughout the mass. Grout was run in wherever possible until no more would be received. The new stones from a quarry, known to be of good quality and cut to ½-in. joints all round, were then slid into place on a bed of rich cement mortar. The top bed joint was then filled by stiff mortar thoroughly rammed in, and the side joints filled by the use of a sword in the usual way. No settlement occurred and no further cracking has been observed.

Mr. Parsons.—In reply to Mr. Flagg, the superstructure was held up during the lifting process entirely by the hydraulic jacks, but after it was lifted clear of the masonry, blocking, as shown by the illustration, was introduced, and the jacks were set up from time to time, so that the load of the superstructure and of the trains was carried by both blocking and jacks; either, however, would have been sufficient to do the work.

As to the original structure, I think there was a decided lack of good engineering advice, and when the pier was encased after it had commenced to fail, it was done by the superintendent of the road without, I believe, any engineering direction.

Originally the builders were entirely misled by the appearance of the shale rock, which looked hard, and was hard, but which disintegrated in the course of time.

The second pier has not yet been repaired, the concrete jacket still being in place. The work described was commenced in November and ended in December. We did not care to undertake any more work at that season of the year than was absolutely necessary. The cracks in the second pier were seen, however, to be increasing. I satisfied myself that this was due to the rain water freezing and thawing, as the weather was wet and alternately cold and warm. I had all the cracks very carefully gone over, cut out, filled with cement, and carefully covered up so as to prevent any rain water from running in. This stopped the deterioration of the jacket during the winter. It was, however, but a temporary expedient, and the pier will soon have to be rebuilt.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

TRANSACTIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

713.

(Vol. XXXI.—June, 1894.)

THE RECONSTRUCTION OF A PORTION OF THE SUBSTRUCTURE OF THE JOHNSONVILLE BRIDGE.

By WALTER H. GAHAGAN, Assoc. M. Am. Soc. C. E.

READ MAY 16TH, 1894.

WITH DISCUSSION.

The writer recently finished, in the capacity of Superintendent of Construction, the removal of three old piers and the building of two new ones, for a portion of the Johnsonville Bridge. This bridge is the crossing of the Nashville, Chattanooga and St. Louis Railway over the Tennessee River at Johnsonville, Tenn., about 80 miles west of Nashville.

In March, 1893, Hunter McDonald, M. Am. Soc. C. E., Chief Engineer of that road, asked for proposals for the construction of a new draw bridge at Johnsonville. This paper will present a description of the old piers and some of the interesting features of the work of constructing the new.

The old piers were built in courses varying from 12 to 30 ins. in thickness. The face stone had been carefully cut and laid with headers and stretchers, and the backing filled in with rough pieces of stone

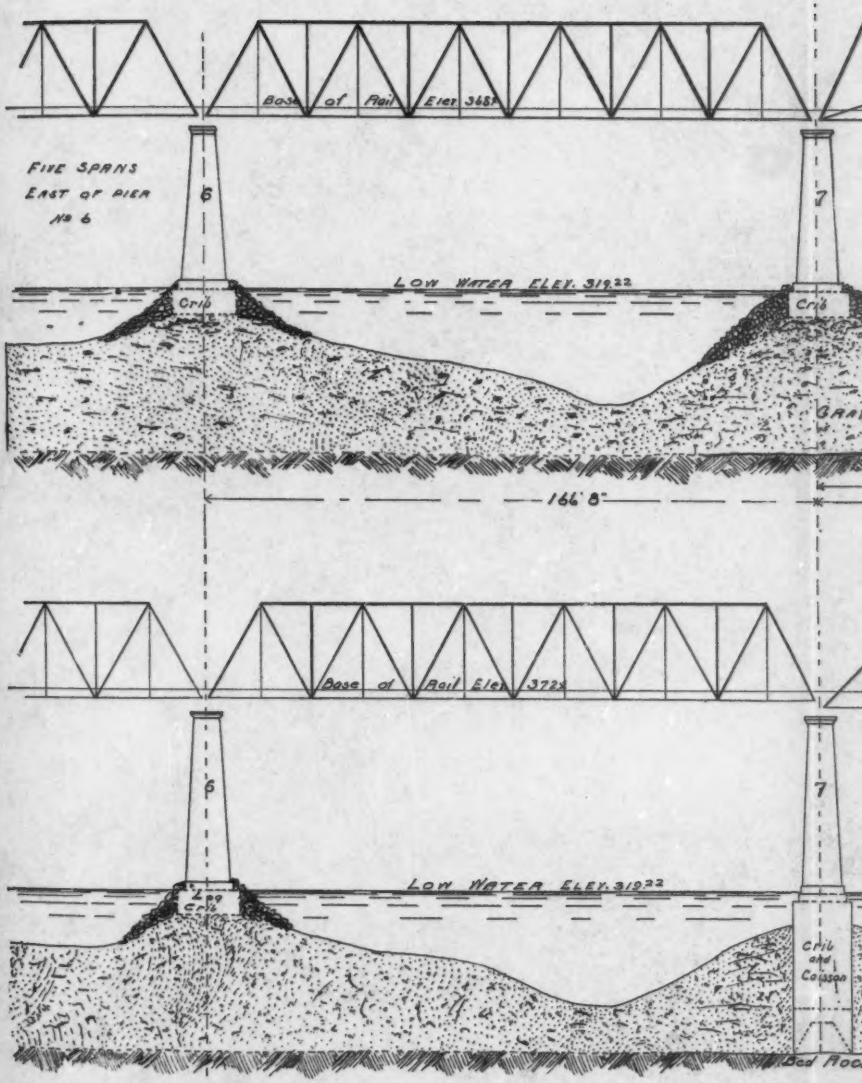
which would be classed as large and small rip-rap. The stone had been laid without mortar of any kind, and the piers seem to have stood remarkably well. In the lower portion of the piers the high water had left silt and sediment until all the voids in the masonry were entirely filled. In the upper portion of the piers there had been poured, in late years, cement mortar grout which filled some of the voids and assisted to bind this part of the piers together. All of the piers had large cracks in them, caused by unequal settlement of the foundations. There had also been a settlement of one of the piers of about 6 ins. more on the down-stream end than on the up-stream end. They were also considerably out of plumb in the other direction.

These old piers were founded about at low water upon rough timber cribs which rested upon the gravel of the river-bed. Upon removing these old cribs we found them to be built from 6 to 7 ft. high, from round logs of poplar and oak timber. The logs were sized one way and halved at the ends. Round drift bolts, $\frac{5}{8}$ in. diameter, had been used to fasten them together. These cribs had been filled with rip-rap stone. Very large stone, having an area of 8 to 16 sq. ft., were laid in a course near the top. Most of this top course of rip-rap stone, as well as those in the footing course of the piers, were found to be broken from unequal pressure when they were removed.

The old piers, 7, 8 and 9, as shown on Plate LXXXIII, were torn down. The foundation cribs, and all material surrounding them, were removed to a depth of 8 ft. below low water. As will be seen by Plate LXXXIII, the old cribs were set upon the gravel bed of the river and were protected by dumping rip-rap around them. This materially reduced the section of the river and caused scour. Additional rip-rap was thrown in for protection as the scour increased, until the scour reached to within a few feet of bed rock below the piers.

By examining the profile sections on Plates LXXXIII and LXXXIV, it will be seen that the piers rested upon a mound of gravel protected by rip-rap. The depositing of this rip-rap around the piers and in the already narrow openings was beginning to interfere with the passage of boats through the draw. It was necessary, during the construction of the new piers, to permit the draw span to swing at any time for the passage of large and small boats, which averaged between one and two boats each day.

In the invitation for proposals, furnished by Mr. Hunter McDonald,


Base of Rail Elev. 348?
FIVE SPANS EAST OF PIER No 6
6
7
LOW WATER ELEV. 319.22
Crib
Crib
166' 8"
Base of Rail Elev. 372?
6
7
LOW WATER ELEV. 319.22
Crib and Caisson

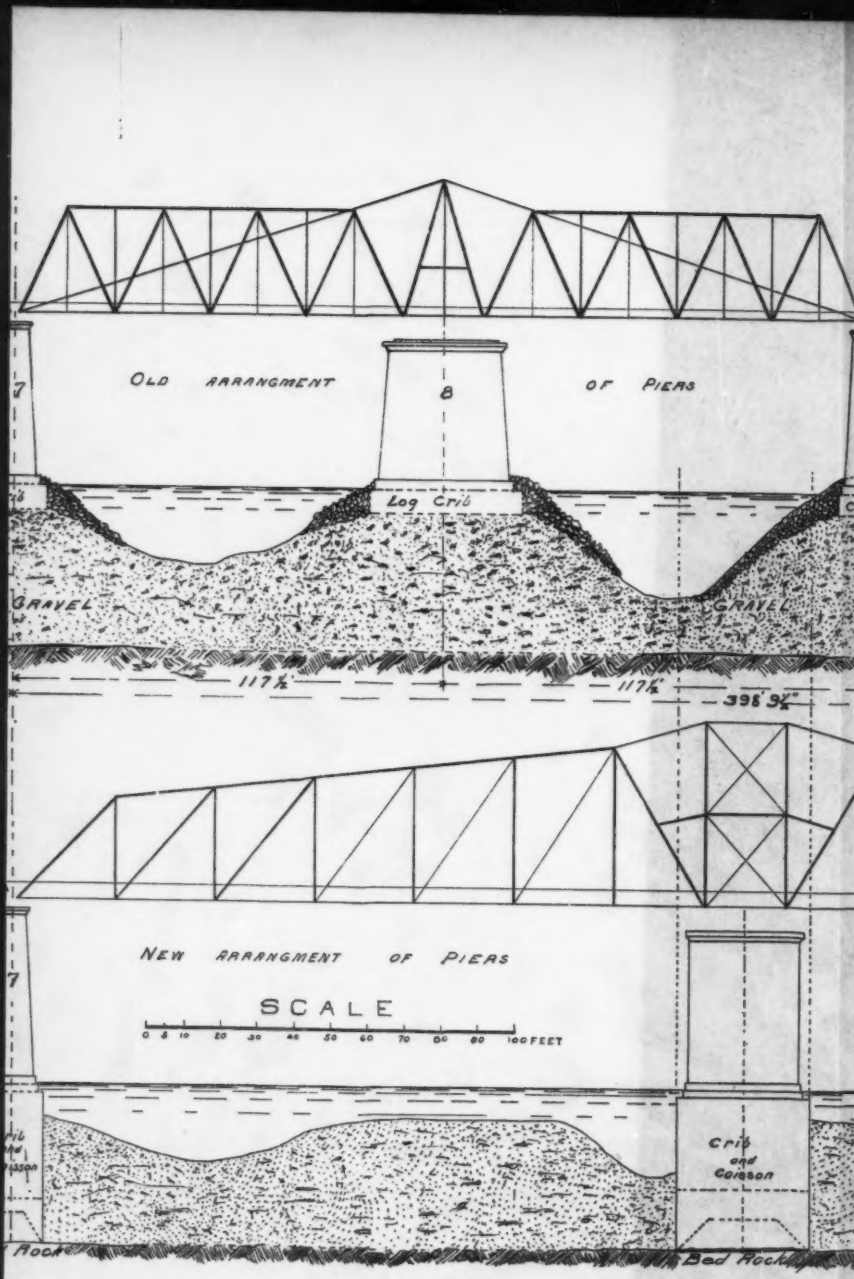
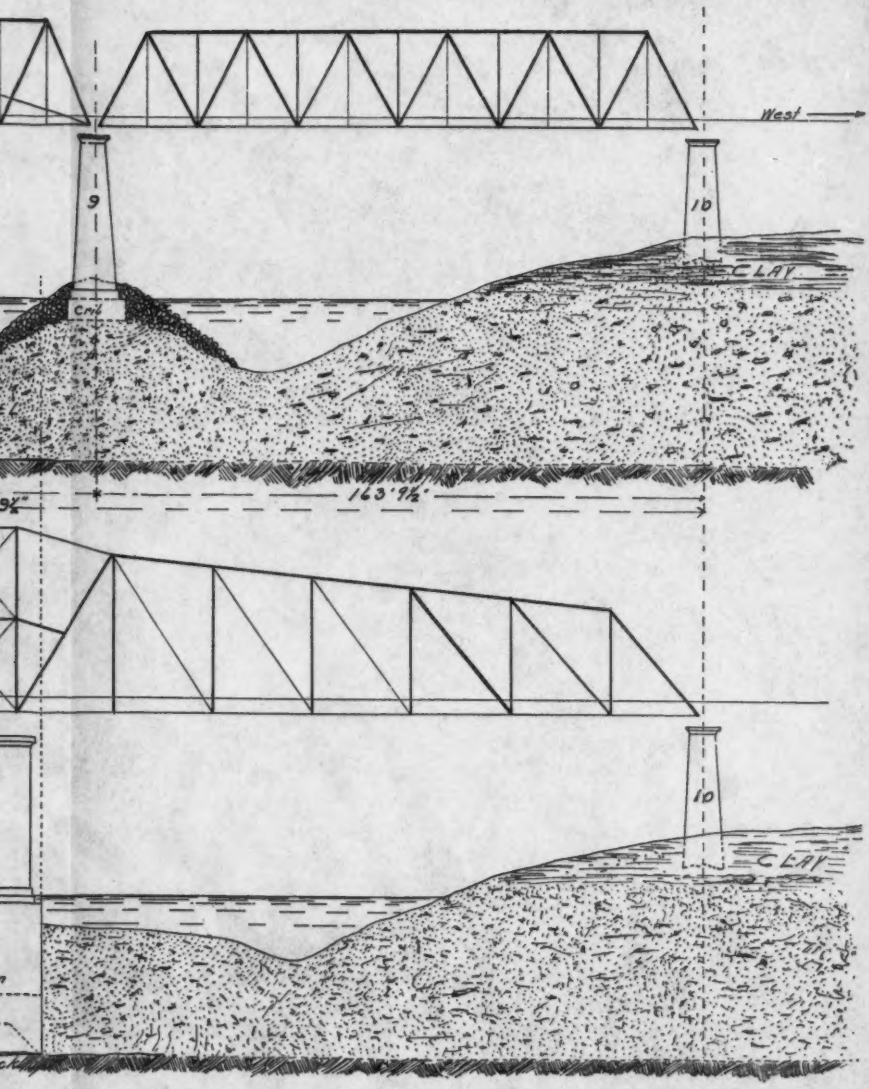
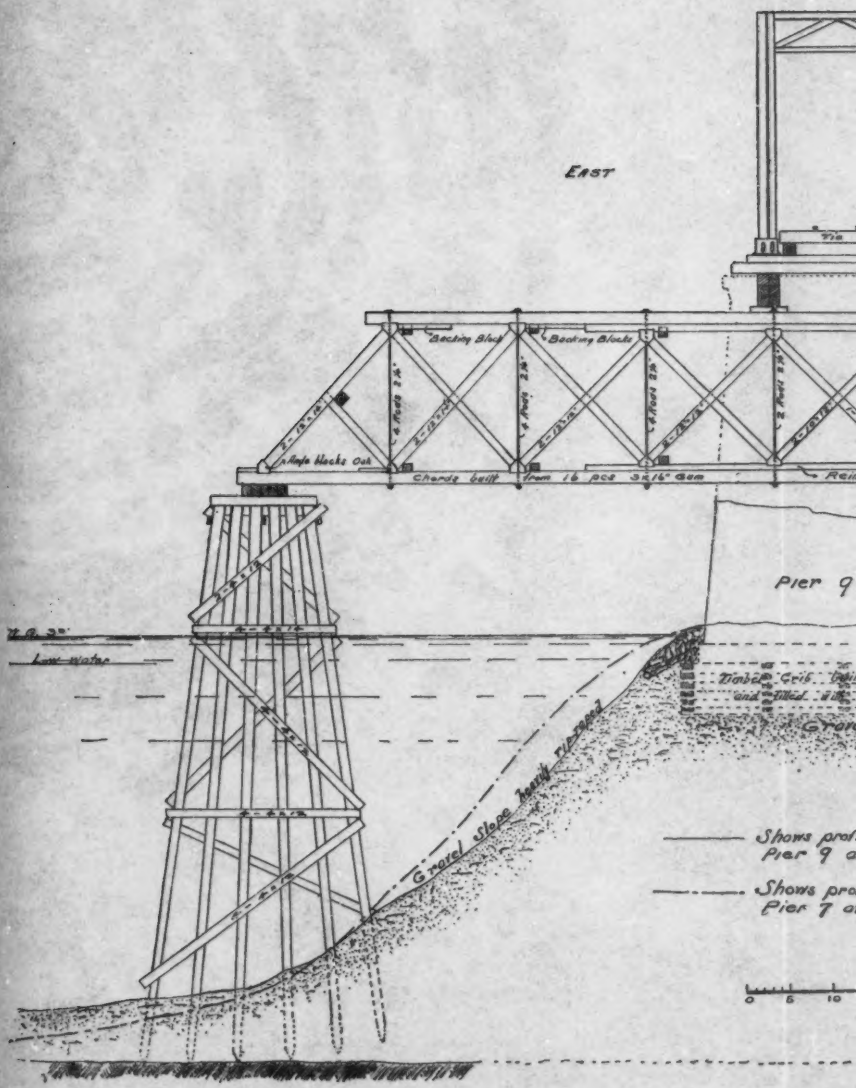
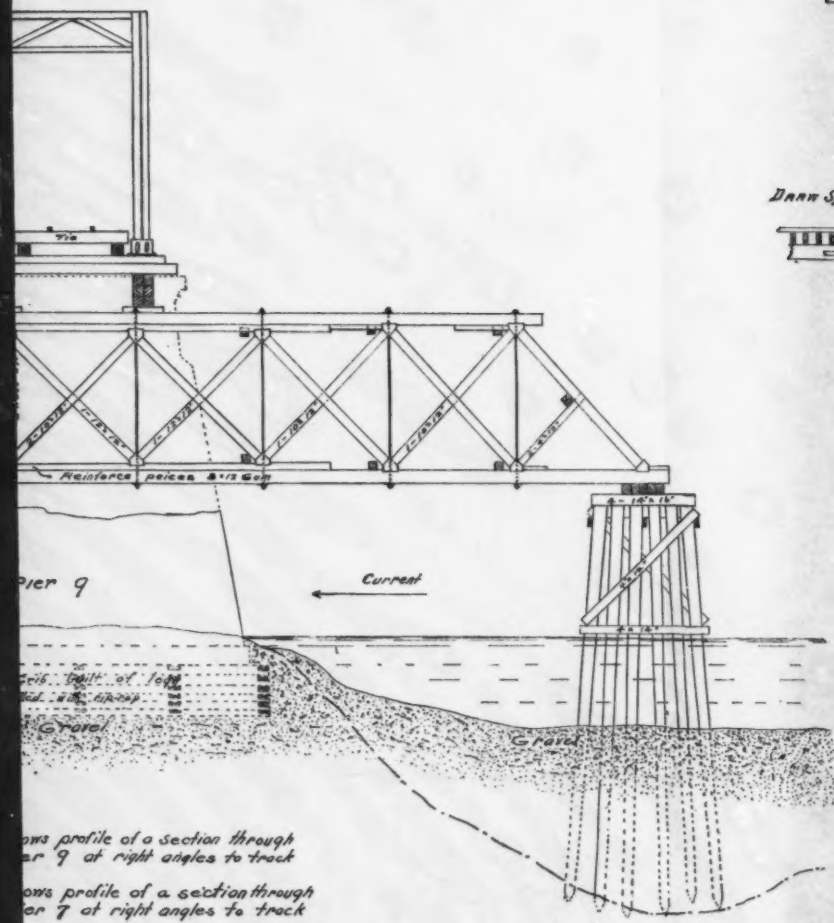

OLD ARRANGMENT OF PIERS
8
Log Crib
GRAVEL
GRAVEL
117½'
117½'
398 9½"
NEW ARRANGMENT OF PIERS
SCALE
0 5 10 20 30 40 50 60 70 80 90 100 FEET
Crib and Caisson
Bed Rock

PLATE LXXXIII.
TRANS. AM. SOC. CIV. ENGRS.
VOL. XXXI, No. 713.
GAHAGAN ON JOHNSONVILLE BRIDGE.



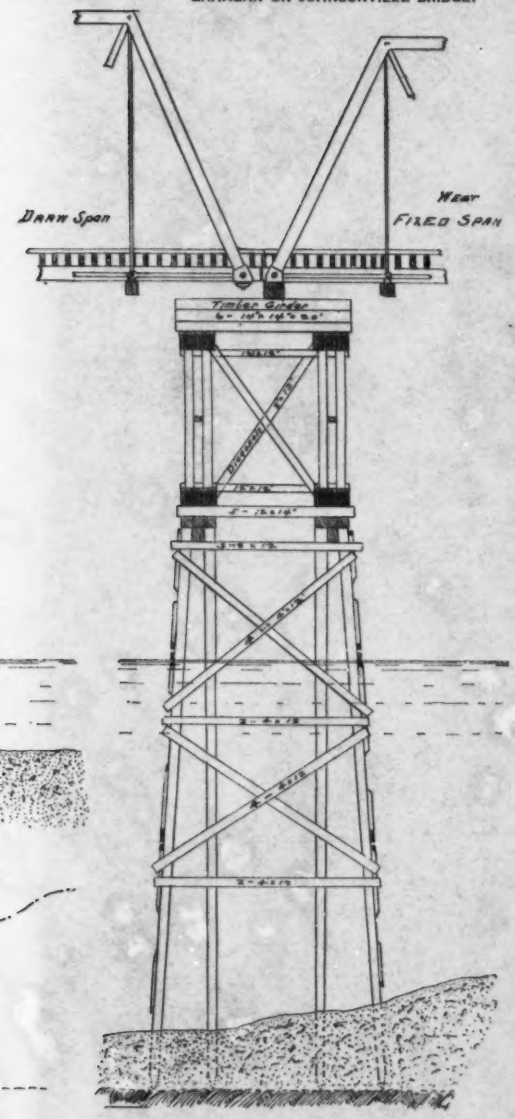

EAST
Backing Block
Backing Blocks
Maple Blocks Oak
Chords built from 16 pcs 3x16" Gum
Pier 9
Low water
Gravel Slope heavily rip-rapped
Shows prof
Pier 9 a
Shows pro
Pier 7 a
0 5 10

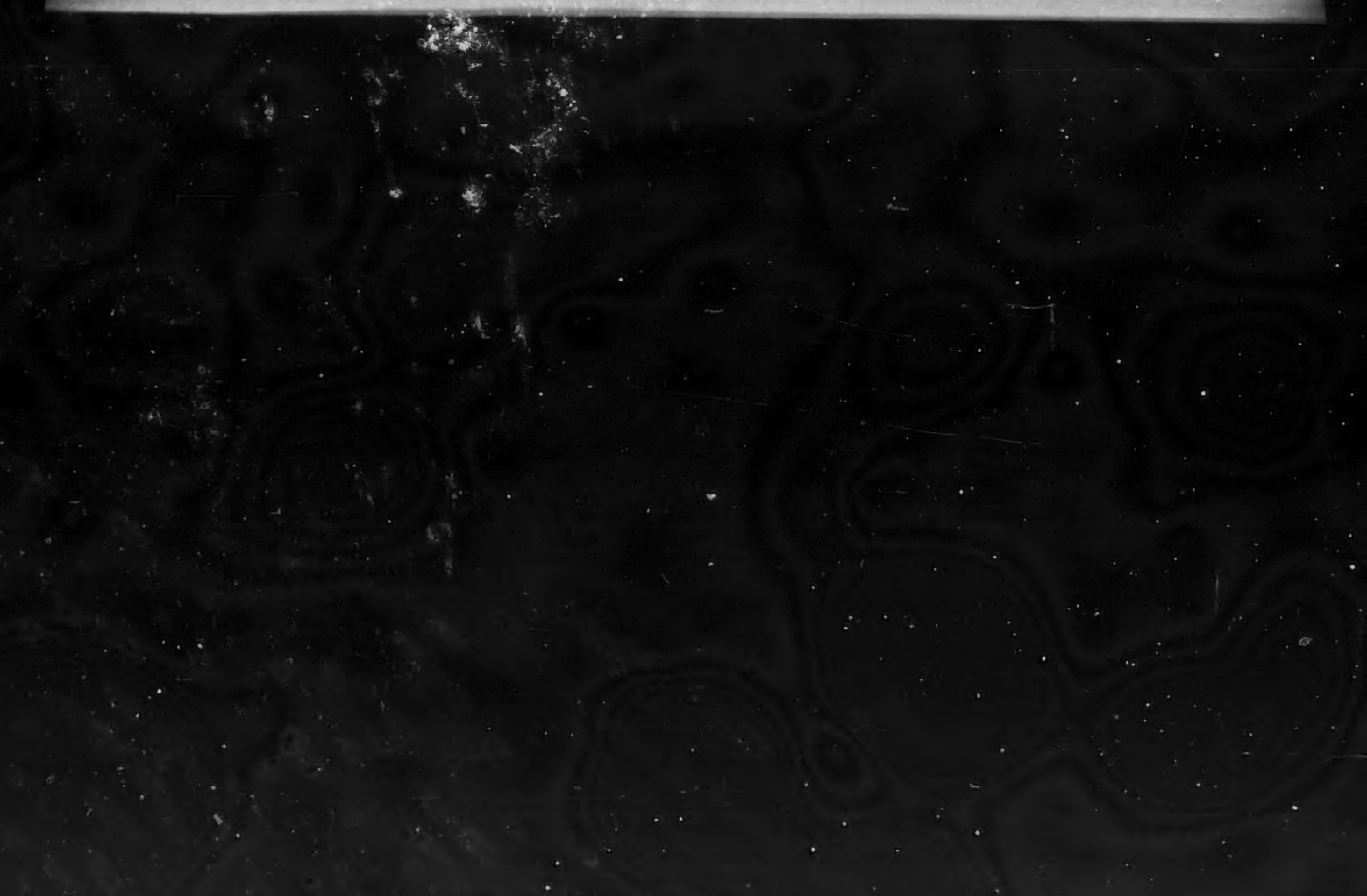


ows profile of a section through
er 9 at right angles to track

ows profile of a section through
er 7 at right angles to track

PLATE LXXXIV.
TRANS. AM. SOC. CIV. ENGRS.
VOL. XXXI, No. 713.
GAHAGAN ON JOHNSONVILLE BRIDGE.





it was required that a new pier be erected directly in place of old pier 7, and a new pivot pier at a location shown on Plate LXXXIII. Also, required to support old spans 6–7, 7–8, 8–9 and 9–10, in such a manner as to admit of the safe passage of all trains and steamboats until the work was completed. The proposals suggested a method of supporting the old spans while the new piers were being constructed. Two trusses, 60 ft. center to center of end pins, would have been furnished to the contractor by the railroad company. The pneumatic method of sinking was preferred, but other methods would be considered. Also, the contractor was required to furnish a complete description of the method to be used in sinking foundations and supporting the old spans, accompanied by drawings and specifications.

The substructure work was awarded to the H. S. Hopkins Bridge Company, of St. Louis, Mo. Mr. Frank D. Moore, C. E., Vice-President of that company, designed and furnished the working drawings for two caissons and the two trusses and pile piers shown on Plate LXXXIV.

The H. S. Hopkins Bridge Company then made an arrangement with McGee, Kahmann & Co., of Kansas City, Mo., by which all of the work agreed to be done by the former party should be superintended and performed by the latter.

Supporting the Old Spans.—At one time it was the intention to adopt the method of supporting the old spans as shown on Plate LXXXIV, at pier 7 only. This method consisted in erecting two heavy trusses, one each side of the pier to be removed, and at right angles to the track. These trusses to be supported by pile piers, these pile piers to be driven far enough from the old piers so that the driving would not disturb the slopes of the material upon which the old pier rested. Also, to have these pile piers far enough away from the site of the caisson to be sunk, so as not to be disturbed by this sinking; these trusses to be braced together. Blocking to go on the top chords to support the ends of the old spans. The end for the draw span being arranged so it could swing and be latched with no more trouble than when it rested upon the old piers.

At old pier 9 it was attempted to use the old method of driving piles each side of the pier and near to it. Upon these piles timber bents would be erected, which would support the ends of the spans while the new pivot pier was being sunk. In June the work of driving

these piles for this second plan was commenced at the west side of old pier 9. After three or four piles had been driven, the top of the old pier had settled 4 ins. toward the west. After this experiment it was not considered safe to do any more pile-driving near or around old piers 7 or 9 which would disturb the slopes of the mounds upon which these piers rested. This latter plan was then abandoned, and it was decided to use the two trusses at old pier 9 first, while the pivot-pier caisson was being sunk, then remove them to pier 7, for use there.

On July 1st the writer was placed in charge of the work by the contractors as Superintendent of Construction. At this time most of the material for the trusses and the caissons was still uncut by the mills. All of the material for the trusses was green and unseasoned; none suitable could be gotten in any other condition. The chords of the trusses were made from 16 lines of 3 x 16-in. gum timber, in lengths from 17 to 43 ft. reinforced by 8 x 12-in. gum timber. This made the cross-section of the chord at its middle 4 ft. wide and 2 ft. deep. The vibration braces were of 12 x 12-in. and 8 x 12-in. materials. The top and bottom laterals were of 4 x 12-in. materials. The angle blocks were framed from a piece of green oak timber 16 x 20 ins. x 4 ft. Each truss was divided into 9 panels, 14 ft. 6 ins. each. The vertical distance between the centers of the angle blocks of the top and bottom chords was 16 ft. 6 ins. for the end panels, and 15 ft. 2 ins. for the four middle panels. The trusses were placed 15 ft. center to center, and were 130 ft. 6 ins. from center to center of end angle blocks, or 136 ft. 6 ins. over all.

These trusses were framed and erected before any of the timber had time to season. The seasoning took place after the load was on the trusses and made it necessary to give them a good deal of attention in tightening up bolts and taking up on the vertical rods. As the timber seasoned and shrunk the angle blocks reduced in size from $\frac{1}{8}$ to $\frac{1}{4}$ in. With the dead load of the old spans, and trains passing every few hours, we could not take this shrinkage up by screwing up on the nuts of the vertical rods, and the trusses sagged so the center was $5\frac{1}{4}$ ins. lower than the ends before the timber became seasoned. Part of this settlement may have been due to the fact that the members were all heavy and large, and a perfect bearing was not obtained until the load came upon the trusses. The writer believes, however, that it was nearly all due to the seasoning and shrinking of the timber.

These trusses remained at old pier 9 until after the first pivot caisson had been sunk to the bed rock and the working chamber sealed. Old pier 9 had been removed in the meantime.

Sixteen piles were then driven from the track on the bridge between the trusses forming a pier for the support of the ends of the spans, so that the trusses could be taken down and re-erected at pier 7. In removing these trusses the top and bottom chords were not unpacked; they were picked up bodily and lowered into the water, then floated to pier 7, where they were picked up again and put in place when the trusses were re-erected. One bottom chord piece weighed 44 000 lbs. and was 108 ft. long as it was lifted into place at pier 7.

When the trusses were re-erected they were shortened one panel on each end, making seven panels of 14 ft. 6 ins. instead of nine panels. This change was made because the pile pier on the down-stream side was more exposed at pier 7 than at pier 9, and more likely to be run into by passing steamboats. It was desired to have more material around the points of the piles to make the pile piers as stiff as possible (see Plate LXXXIV).

After the trusses were in place the second time, the timber was pretty well dried out and there was no shrinking or sagging from the bearings first taken.

The timber girders which rested upon the top chords of the trusses were framed from six pieces of 14 x 14 ins. x 20 ft. gum timber. They were bolted together and keyed. To get the timber girders in place a portion of the old pier had to be removed (see Plate LXXXIV). A good deal of raising and lowering of the fixed spans was necessary, which was done by hydraulic jacks.

There were four pile piers, 12 piles in each pier, or 48 piles to support the two trusses. The piles for the deep water were ordered 68 to 70 ft. long and were 10 to 12 ins. in diameter at the small end. They were of oak and gum timber. In driving the piles the points were spread apart and the tops pulled into place under the caps. This was done to make the pile pier as stiff and stable as possible to withstand the force from barges and boats running into them. Sway bracing was bolted on by a diver, as shown on Plate LXXXIV.

The Pneumatic Caissons.—There were two caissons. That for the pivot pier, the dimensions of which were 36 x 36 x 16 ft., surmounted by a timber crib 36 x 36 x 25 ft., filled with concrete; and the smaller

caisson for the new draw rest pier 7, the dimensions of which were 16 ft. 9 ins. x 40 ft. 6 ins. x 12 ft., surmounted by a timber crib 16 ft. 9 ins. x 40 ft. 6 ins. x 29 ft., filled with concrete. The distance in each pier from the cutting edge of the caisson to the top of the crib or the bottom of the masonry pier was 41 ft. In each caisson and crib its horizontal section was the same throughout. The timber used was of white oak, excepting a few long pieces used in the working chamber for ties and struts and in the course built in the decking. These were of gum, because of the difficulty of getting oak sawed in sticks longer than 30 ft.

The design of these caissons is not particularly new or sufficiently different from other familiar forms to warrant a description here. Had the caissons for these piers been sunk in any open river, the work would have been interesting probably only from a commercial, not an engineering, point of view.

The old piers 7 and 9 were removed and the two new piers were built without interfering with the traffic of the road in any way.

The caissons for both of the piers were built upon the shore above the bridge, launched and floated into position at the pier sites when needed. The timber from which they were built, being of green oak, made it necessary to build a false bottom in each caisson, for neither could have been made to float without the use of some artificial means.

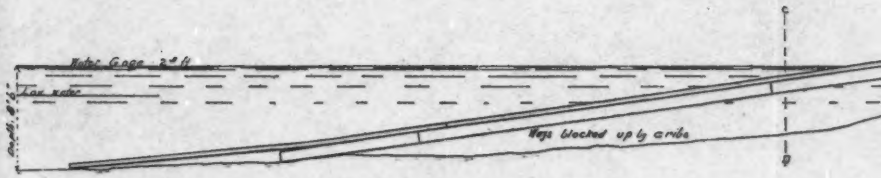
The position in which the pivot pier caisson was built is shown on Plate LXXXV. The plate is given to show into what shallow water a heavy caisson may be launched.

The launching ways were built well out into the river when they were constructed, to get into as deep water as possible and not have the grade of the ways too flat. The friction planks were extended beyond the ends of the heavy skidding timbers to change the grade and prevent the caisson from plunging into the mud and gravel and sticking fast as it ran off of the ends of the skid timbers.

When the work of building the caisson began, in June, the water was deep enough, but by the time we were prepared to launch the caisson there was barely enough water to float it at the end of the launching ways. The weight of the caisson ready to launch was 552 000 lbs. This includes the air lock and lower sections of shafting, cutting edge, and other iron bolts and drift bolts. The line of

SECTION THROUGH C D

Total weight of Caisson as launched 552000
Caisson would draw from the line of immersion
to the bottom of launching shoe. 6ft 1 ins.



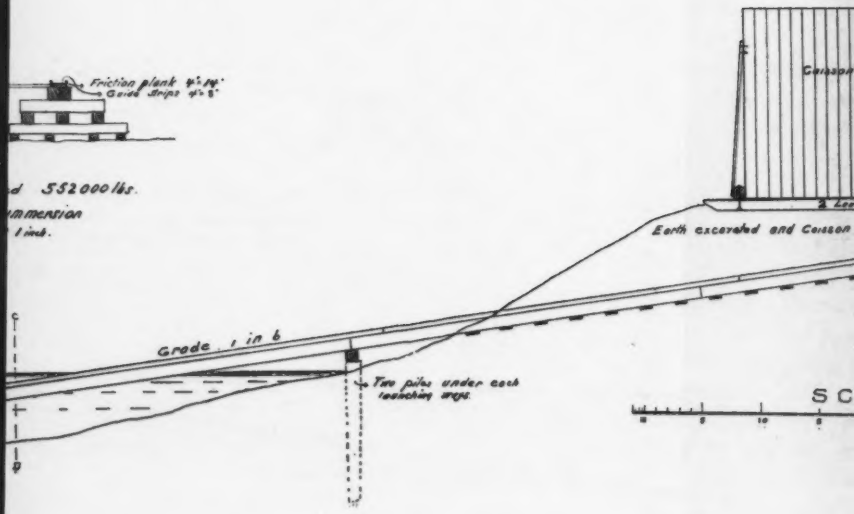
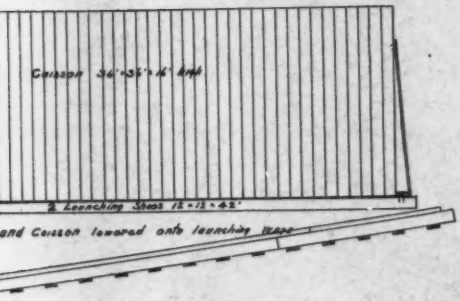
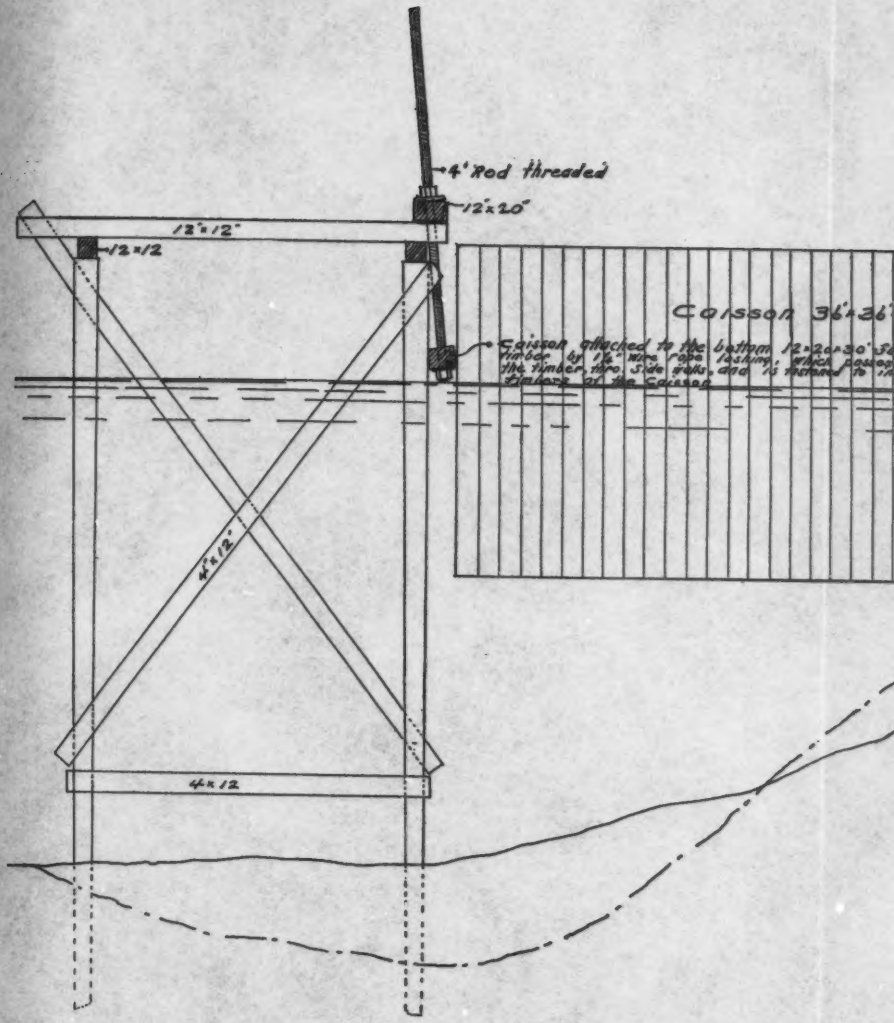

Friction plank
Guide Strips
552000 lbs.
Caisson
Earth excavated and Caisson
Grade 1 in 6
Two piles under each
toothing strips

PLATE LXXXV.
TRANS. AM. SOC. CIV. ENGRS.
VOL. XXXI, No. 713.
GAHAGAN ON JOHNSONVILLE BRIDGE.




4" Rod threaded
12"x20"
12"x12"
12x12
Caisson 36'x36'
Caisson attached to the bottom 12x12x30' Sa
timber by 1/2" wire rope lashing, also fasten
the timber thro. side grds. and is fitted to
timbers of the Caisson
4"x12"
4x12

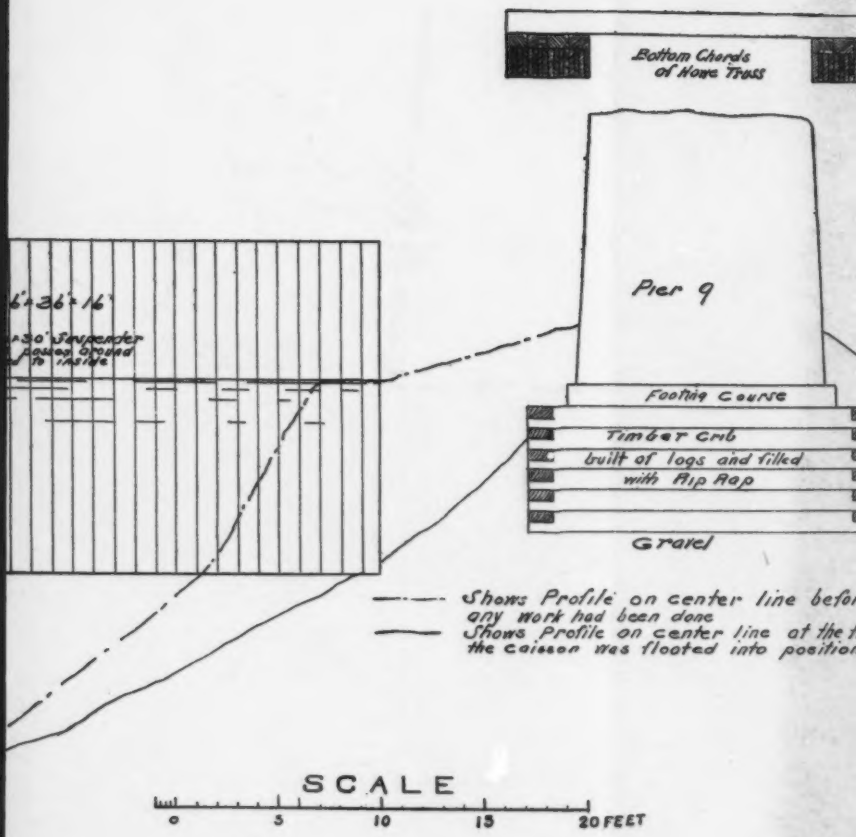
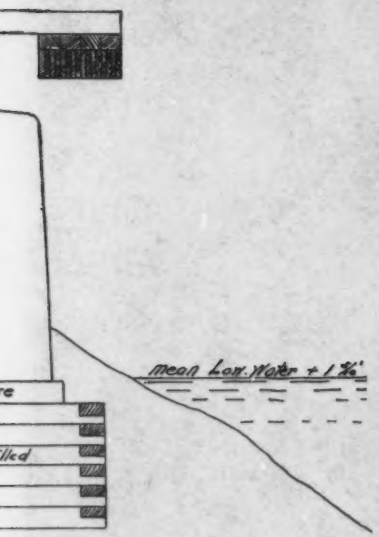

Bottom Chords of Howe Truss
Pier 9
Footing Course
Timber Crib
built of logs and filled
with Rip Rap
Gravel
Shows Profile on center line before
any work had been done
Shows Profile on center line at the t
the Caisson was floated into position
SCALE
0
5
10
15
20 FEET

PLATE LXXXVI.
TRANS. AM. SOC. CIV. ENGRS.
VOL. XXXI, No. 713.
GAHAGAN ON JOHNSONVILLE BRIDGE.



ne before
at the time
position

immersion was calculated as 8 ft. 1 in. above the bottom of the launching shoe, which was fastened to the caisson. The depth of water into which the caisson was launched was 8 ft. 6 ins.

Only two of the eight courses of decking were put in place before the launching. The balance were built in after the caisson was in place at the pier site. The false bottom for the pivot pier caisson was not caulked. It was made from 2 x 12-in. poplar; under this was put 1 x 5½-in. dry poplar tongued and grooved stuff. The joints were painted as this matched stuff was put on. Around the outside of the false bottom, next the cutting edge, a roll of oakum was laid in between the matched stuff and the 2 x 12-in. poplar. The false bottom leaked a good deal at first. It answered the purpose, however, and was built very quickly and cheaply.

After the caisson was launched, it was immediately floated down near the bridge into water about 10 ft. deep; we permitted it to fill, and let it settle on the bottom and remain there a few days. When we were ready to float the caisson into position on the pier site, the bottom had swelled, so there were few leaks, and the working chamber was easily pumped out with a Worthington pump of 4-in. suction. After the water had been pumped out, a hand pump would keep it down.

On Plate LXXXVI in the dotted line is shown the profile of the site for the pivot pier before any work had been done (the same profile is shown on Plate LXXXIII on a smaller scale). After the two trusses were in place at pier 9, the excavation was made, which changed the profile to that shown in the full line. This excavation was made to enable us to float the caisson into position; also to level up the pier site as much as possible. The site for the caisson was still 14 ft. lower on one side than upon the other. This side of the caisson, which could not take a bearing upon the ground, was supported from six piles. These piles were spaced 16 ft. center to center in one direction, and 14 ft. and 28 ft. center to center in the other. These piles were sway-braced to the ground. The braces were bolted on by a diver. This method of supporting the caisson is not new. It is very simple, and is shown on Plate LXXXVI.

Great care was used to keep the weight upon the two 4-in. screws as light as possible until the cutting edge had a bearing over two-thirds of its surface. The material upon which the caisson landed was principally rip-rap. This was removed from the high side next

the old pier, and deposited on the low side opposite. A great deal of this rip-rap was thrown out from under the cutting edge to build up the low side.

In placing the concrete in the crib, the side which hung on the screws was kept as light as possible. The concrete was put in only fast enough to keep it above water. On the side next the old pier which had a bearing upon the ground, the concrete was built up much faster. The leveling up of the bottom consumed five days. After the cutting edge was given a bearing all around, which, as has already been stated, was obtained by excavating on one side and filling up on the opposite side, the concrete was built up in the crib as rapidly as possible to give weight. This weight was supposed to be heavy enough to prevent the bank of material, and the weight from the lower portion of old pier 9, from crowding the caisson out of position.

The framing for this caisson was begun.....June 19th.
The caisson was launched.....Aug. 13th.
The air compressors were started.....Aug. 16th.
The caisson was landed on bed rock.....Sept. 16th.
Finished sealing the working chamber.....Sept. 20th.
Masonry for the pivot pier finished.....Oct. 14th.

In sinking the caisson there were piles which stood 7 ft. from the face of it which were not disturbed. These piles were driven about 15 ft. into the gravel and stood at the up-stream end of old pier 9. This leads the writer to believe that this caisson could have been sunk by the side of the old pier without disturbing it. The method which was used, however, was perfectly safe and did not take any chances of the settlement of the track and interfering with the traffic of the road.

The new draw rest pier No. 7, which was the last to be constructed, was made a very simple piece of work. The two trusses were removed from pier 9 and erected here. Old pier 7 was then torn down and the pier site excavated to a level of 8 ft. below low water. This practically removed all obstructions and left a comparatively level site for the caisson to be landed upon. The sinking was quickly and easily done.

The most difficult work connected with this pier was the masonry, which consumed the most time. Much of this work was done at night because the receiving of materials for it interfered with the superstructure workmen who were raising the grade of the track 4 ft. 6 ins. and

erecting the steel for the new draw span. It was slow work getting the heavy stone on to the pier because of the small amount of room between the trusses for such work.

The time consumed in building this pier is as follows:

Began framing caisson	Sept. 14th.
Finished building	Oct. 8th.
Launched caisson	Oct. 30th.
Started air compressors	Nov. 3d.
Landed on bed rock	Nov. 18th.
Finished sealing working chamber	Nov. 20th.
Finished masonry	Dec. 16th.

The material through which the caissons were sunk was gravel. The caissons rest on bed rock. The cutting edge in the pivot pier caisson is 44 ft. below low water, and that of the small caisson is 44.08 ft. below low water.

The concrete in the caisson and cribs was mixed in the proportions of 1 part of cement, 2 parts of sand, and 5 parts of broken stone. The stone used in the masonry was obtained from the Newsome quarry, which is at Newsome station, 16 miles west of Nashville, on the Nashville, Cincinnati and St. Louis Railway. Masonry backing was used in the piers. The mortar used throughout was made from Louisville cement, mixed in the proportion of 1 part cement and 2 parts sand. The cement was all tested before being used.

The quantities, as measured in the finished piers, and their cost, are as follows:

PIVOT PIER.

119 792.4 ft. B. M., timber in caisson, at	$38 00	$4 552 11
95 727.5 ft. B. M., timber in crib, at	28 00	2 680 37
54 975 lbs. iron in caisson and crib, at	04	2 199 00
96 linear feet shafting, at	7 00	672 00
44 linear feet sinking below low water, at	344 83	15 172 42
313.4 cu. yds. material locked out, at	35 00	10 969 00
1 085.9 cu. yds. concrete in crib and caisson, at	6 00	6 515 40
233.5 cu. yds. concrete in air chamber, at	12 00	2 802 00
Total for caisson and crib		$45 562 30
2 112 cu. yds. displaced by caisson and crib, at	21 57	$45 562 30

MASONRY OF PIVOT PIER.

415.62 cu. yds. face stone, at	$12 00	$4 987 44
725.19 " backing, at	7 00	5 076 33
24.52 " coping, at	16 00	392 37
Total cost of masonry		$10 456 09
1 165.33 cu. yds. masonry, average cost	8 97+	$10 456 09
Total cost of pivot pier		$56 018 39

DRAW REST PIER No. 7.

54 950 ft. B. M., timber in caisson, at	38 00	$2 088 10
60 097 ft. B. M., timber in crib, at	28 00	1 682 72
40 964 lbs. iron in caisson and crib, at	04	1 638 56
108 linear feet shafting, at	7 00	756 00
44.08 linear feet sinking below low water, at	217 01+	9 565 87
17 cu. yds. material locked out, at	35 00	595 00
564.2 cu. yds. concrete in crib and pockets, at	6 00	3 385 20
108 cu. yds. concrete in air chamber, at	12 00	1 296 00
Total for caisson and crib		$21 007 45
1 107.51 cu. yds. displaced by caisson and crib, at	18 96	$21 007 45

MASONRY OF PIER No. 7.

351.39 cu. yds. face stone, at	12 00	$4 216 68
124.72 " backing, at	7 00	873 04
15.78 " coping, at	16 00	252 48
Total cost for masonry		$5 342 20
491.89 cu. yds. masonry, average cost	10 86	
Total cost of draw rest pier		$26 349 65

DISCUSSION.

H. G. KELLEY, M. Am. Soc. C. E. (by letter).—The paper presented by Mr. Gahagan relates to a class of work which has been increasing within the last few years, and is due to the rapid enlargement in the volume of railroad traffic, necessitating heavier motive power and consequent wearing effect upon structures built for lighter service, and during a period when the financial necessities of railroad enterprises precluded large expenditures.

The responsibilities resting upon the engineers in charge of such structures, and the grave difficulties encountered in replacing or strengthening them, can hardly be appreciated by those whose experience and practice has been entirely with new work, but its importance merits careful attention and ample discussion from the members of this Society.

The writer of this discussion recently presented to the Society a paper upon a piece of work of this class, entitled "The Removal of a Defective Pivot Pier and its Reconstruction." He was also called upon in 1890 to perform another piece of work of the same kind, of even more importance, although not more difficult than those above mentioned. He can therefore appreciate the difficulties encountered by Mr. Gahagan, and the skill with which they were overcome, and desires to call attention to some of the principles governing work of this class, the dangers to be apprehended, and, incidentally, to present a history of a piece of work completed in the Arkansas River, which developed some valuable knowledge.

GOVERNING PRINCIPLES AND CONDITIONS.

First.—The traffic of the road must be continuously provided for without interruption.

Second.—If the stream is navigable, the traffic of the river must not be interrupted or stopped, for all such interruptions are followed by claims and suits for damages.

Third.—The freedom of the work is contracted by the superstructure overhead, limiting the space and preventing the convenient location and use of hoisting engines and derricks.

Fourth.—If the original piers were not founded upon bed rock, hardpan, or a strata of gravel upon which the new ones are also designed to rest, settlement of the original structure can be expected, with all the attendant dangers and expenses, and also liability of collision with the new pier.

Fifth.—The temporary contraction of the water-way increases the scour of the river bed, and may endanger the stability of the original piers.

Each case requires different treatment and a thorough study of the

surrounding conditions, as well as an intimate knowledge of the action of different soils under pressure with the influence of water.

By reference to Plate LXXXIII of Mr. Gahagan's article, which is drawn to natural scale, both vertical and horizontal, it will be seen that the scour had been exceedingly heavy, leaving the old piers upon a very insecure footing. Had the river bottom been other material than gravel, they could not have stood. Their insecurity is shown by the paragraph on pages 589 and 590, where it is stated that upon an attempt to drive piling within a few feet of pier 9, a settlement of 4 ins. occurred, throwing the pier out of position to the west, indicating the danger to be apprehended by disturbing the foundation material when the caisson was being sunk. The use of the auxiliary truss removed this danger and advanced the work to the second stage, where the caisson was placed in position ready for sinking.

Referring to that paragraph on page 590, mentioning the sagging of the auxiliary truss, it is not quite clear why the shrinkage could not be taken up, whether it was from the lack of sufficient thread on the tie rods, or on account of the weight supported by the truss; if the former was the reason, the difficulty could have been remedied by slacking away on one rod at a time, and putting a thick oak block underneath the nut on the top chord, and adjusting the entire span after all rods had been blocked; the writer has done this upon Howe truss spans of 125 ft. without difficulty.

The delicacy required in handling a pivot caisson suspended at one end and resting on a gravel bank at the other will be appreciated by those experienced in pneumatic work; but it is questionable if there would have been as little pressure from the bank tending to throw the caisson out of position, as was indicated, had it not been for the fact that the old pier 9 had been taken down and the load from the superstructure was carried by the auxiliary span.

Referring now to a similar piece of work in the Arkansas River, completed in 1891, a short history of the road and the conditions leading up to the necessity of the work will render the description more clear. In the year 1883, the Texas and St. Louis Railway was built from Waco, Tex., to Bird's Point, Mo., opposite Cairo, Ill., a total distance of 720 miles. This railroad was built upon the narrow-gauge system, the gauge being 3 ft., and all the bridges were built for light-weight engines and cars.

In 1887, the road changed ownership, and was widened to the United States standard gauge of 4 ft. 8½ ins. Heavier engines and cars then being constructed, it became necessary to remove all defective or inadequate structures and replace them with structures calculated to carry modern engines and trains. The writer personally assumed charge of this work in 1888.

Among the principal streams crossed was the Arkansas River, which was spanned by the following structures: Two spans of 100 ft. each,

combination wood and iron; five spans of 200 ft. each, combination wood and iron; one draw or swing span of 355 ft., iron.

These fixed spans were supported upon wrought-iron cylinders 7 ft. in diameter, filled with concrete. All of the combination spans were replaced in 1888 upon the original piers, but the draw span was carried until 1890. At this time the management desired to still further increase the weight of the engines used, and a thorough examination of the draw span and pivot pier resulted in a condemnation of both, the pier having already shown a movement to the north and signs of failure, this movement having been sufficient to block the opening of the draw, and requiring the removal and adjustment of some of the timbers in the end of the 100-ft. combination span adjoining it. This pivot pier consisted of a central cylinder 6 ft. in diameter, surrounded by six cylinders, 4 ft. in diameter, each braced together by latticed channel irons and tension rods. These cylinders were recorded to have been sunk in their construction to a depth of 68 ft. below extreme low water, with the exception of two of the small cylinders which had been stopped at about 40 ft. penetration, but no record was left to show which of these cylinders they were. The Arkansas River is navigable at all seasons of the year, and the cost of damages sustained by the river boats during the time in which the channel might be closed was an important item of expense to be considered in comparing the different plans for the reconstruction. The river is also subject to extreme floods, making all work hazardous, and the maintenance of false work especially dangerous. It was considered impracticable to attempt to obstruct the channel with false work, take down the old spans, and then remove the pivot pier by sinking a pneumatic caisson immediately above; for, besides the cost of damages to the navigation interests, the delay and expense of breaking up the old cylinders and taking them out through the air-lock of the caisson would have been exceedingly great.

The Department of War of the United States Government had fixed 160 ft. as the least clear channel-way that would be allowed; the only way, therefore, to overcome the difficulty was to increase the total length of the new draw span to admit of a masonry pivot pier to be sunk by the pneumatic method far enough in front to clear the old pivot pier and be in line with the axis of the bridge.

The danger to be apprehended was that the old pivot pier would settle while the caisson was being sunk so close to it, and thus not only endanger the old draw span, but cause the two piers to come in collision, and thus cause the destruction of both.

Soundings in the river showed the bottom to be of fine sand for a depth of 103 ft. below extreme low water; calculations showed that with a caisson of 32 ft. square penetrating to a depth of 68 ft. below extreme low water and rising to within 5 ft. of extreme low water, upon which would rest a cylindrical masonry pier 28 ft. in diameter and

$35\frac{71}{100}$ ft. high, sufficient stability would be had to carry a draw span of 428 ft. in length, and of the design and weight necessary to carry the established train loads. These dimensions were, therefore, decided upon, and gave 36.5 ft. as the distance between the centers of the old and new pivot piers, or a clear distance between the wall of the caisson and the closest 4-ft. cylinder of but 5.5 ft. (see page 601). This design necessarily required the removal of the old pivot pier and pier 2, and also the building of a new pier "A," shown on the plate; but this latter work involving no new principle, it will not be mentioned.

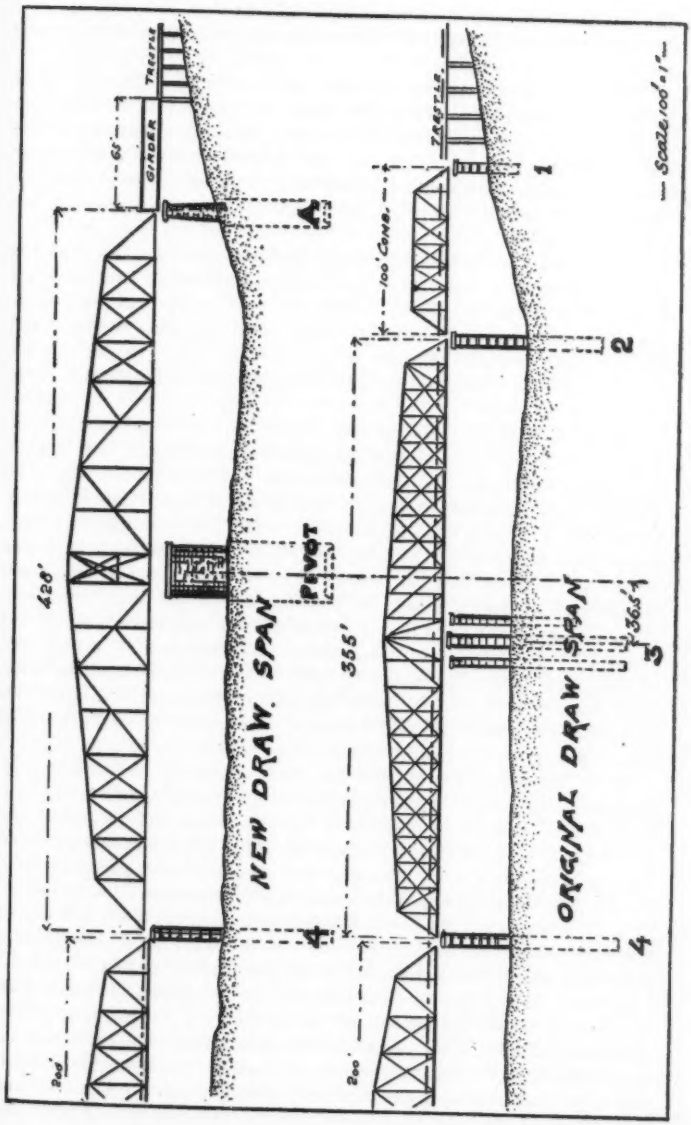
The work was let by contract, and Mr. J. A. L. Waddell, M. Am. Soc. C. E., prepared the caisson and masonry plans and also estimates for the contractor, which plans were approved by the writer. Mr. W. H. Gahagan, then Junior Am. Soc. C. E., was appointed Principal Assistant, and Mr. J. W. Schaub, M. Am. Soc. C. E., prepared the designs for the draw span.

The action of the caisson in descending so close to the existing structure was a matter for consideration; there were two possibilities:

First.—The proximity of the old pier might act like a high, sloping bank of earth and force the caisson out farther into the channel.

Second.—The river bed being composed of fine sand, it would be necessary to keep the caisson load heavier than usual and drop it suddenly and quickly at each settling, to prevent a disturbance in the surrounding sand and movement of the old pier. In this case the sand between the cylinders of the old pier would be obstructed in its flow and probably be more compact than the sand in the river bed; therefore, when the caisson was blown and the sand flowed into the working chamber as it settled, would not the sand coming from between the caisson wall and the old pier leave a partially open void before it could be filled from the surrounding river-bed material, and, the pressure from the channel side being greater, gradually force the caisson closer to the old pier?

The actual result of the sinking proved the second possibility to be correct, but the contractor, naturally holding to the first, set his caisson 2 ft. closer to the old pier than was the correct position, with the result that it was only by the strongest efforts the caisson was kept from colliding with the old pier, and was finally landed 21 ins. closer to the old pier than was intended. The serious nature of the work was thoroughly appreciated and the strictest watch was maintained throughout; the caisson was handled cautiously, but the sinking was executed as rapidly as possible, and no serious delays or emergencies arose throughout the work. It was found, however, that when the caisson had reached a penetration of 40 ft. below extreme low water, the 4-ft. cylinders nearest the caisson showed a tendency to settle, indicating that these were the cylinders not originally sunk to the required depth. This settlement was slight, but was sufficient to throw the bracing of the cylinder cluster into severe tension, and


GIRDER
TRESTLE
65'
420'
NEW DRAW SPAN
PIVOT
355'
100' CONC.
TRESTLE
ORIGINAL DRAW SPAN
365'
Scale 100' = 1"
200'
200'
1
2
3
4
4
4

threw the draw span northward about $\frac{1}{16}$ ft.; this, however, did not interfere with the passage of trains or the turning of the draw span to allow boats to pass through.

When the caisson reached its final penetration of 68 ft., the water in the river stood 20 ft. above low water, giving a total submersion of 88 ft.; the air pipe leading to the working chamber indicating a pressure of 37.5 lbs. per square inch, or the equivalent of 2.5 atmospheres above the normal atmospheric pressure. The men were worked in watches of four hours' duration, and but little trouble was had from "caisson disease."

The contraction of the channel produced a scour of 27 ft. between the new pivot pier and pier "A," which filled up at once when all obstructions were removed. After the new piers had been completed, false work was built in the river, the old spans removed and the new span erected. The old piers were then taken down to 7 ft. below extreme low water, and the river opened for traffic after a total closure of six weeks.

M. WARD EASBY, Assoc. M. Am. Soc. C. E.—I would like to say, relative to some of the streams in western Pennsylvania, that I have had a little experience on the Conemaugh River at Johnstown. The Pennsylvania Railroad bridge is built down to rock. On February 17th, 1890, we had a little high water. After that high water we took soundings alongside of the pier, and found that the bottom of the river had been scoured out over 11 ft. I have also seen a bridge, the foundations of which I had the pleasure of tearing out, which was carried away by the flood in Johnstown in 1889, and which was located about 1 100 ft. below the Pennsylvania Railroad bridge, where two of the piers were undermined by the current. They probably had been put down about 7 ft. below the bed of the river. I built two bridges across that river, and I should recommend going down more than 5 or 6 ft. in that neighborhood if the bridges are to stay.

P. F. BRENDLINGER, M. Am. Soc. C. E.—This is certainly a very interesting paper, and I presume that every engineer, and contractor also, is interested in the removal of the old bridge and piers and the putting in of the new ones. There is one thing lacking in this paper, as there is in many papers. There is not sufficient history given; in fact, there is no history given whatever of the construction of this bridge. That, it seems to me, is a very important omission. It is always best to know the cause of such a construction. Here is a bridge, which is a very important one, built on, I think, as bad a substructure as I ever heard of or saw. It is a pity that the names of the persons who designed or constructed these foundations are not given. Of course, the author may have felt a little delicate about bringing up personal matters, but, at the same time, I think this should be known. The idea of building a pier without mortar in it seems to me perfectly absurd. The cribs are built of round logs and filled in with rough rip-rap stone. The author

does not say whether on top of that stone there was a grillage or timber platform or not; but, judging from his paper, there was not. The masonry was merely put on top of the crib, filled with rip-rap stone, and then built up. The designer may have had something in his mind as to what he would do with it after it was built dry, just as a certain engineer some time ago intended to build tunnel masonry of dry brickwork and then grout it, because we had grouted dry or bad brickwork in the New York aqueduct, with success. There we found dry brickwork and then injected grout to convert it into cemented brickwork; but the idea of designing a structure, putting it up dry and then pumping in grout afterwards, is something that I should think no sane engineer would do.

In looking at this plan, of course, the scale seems very much out of proportion, and it is a pity that it could not have been drawn to a natural scale. The holes that show the river bed to have been scoured out I presume would not look so badly on a natural scale. I do not understand why it is that there is such a tremendous scouring, unless there is a great current, of which there is no mention made at all. I know of but one bridge on the Ohio River (above Wheeling), or the Allegheny and Monongahela rivers that is not built on gravel. I think I built six bridges myself on the Ohio and Monongahela and Allegheny rivers; all but two were on solid timber foundation, resting on the gravel bed. The two exceptions had hollow cribs, sunk to place with stones and topped with a solid platform. The first one I built in 1872. The gravel has a depth of about 40 ft. The bridge is built about 500 ft. below Dam No. 2, Monongahela River, where the current is exceedingly swift. There is one span of 250 ft. and the other spans of 133 ft., about nine in all. The water was about 7 ft. deep, except at one corner of the dam, where it was scoured to 40 ft. We did not go to bed rock, but excavated about 7 ft.; one crib was built 14 ft. deep. But there is no dry masonry in those piers. As I say, that bridge was built about 22 years ago. I have never heard of any settlement or any scouring taking place. The piers were, of course, well rip-rapped.

On the bridges of the Vanderbilt system across the Monongahela River and the Youghiogheny River we built solid timber cribs on top of the gravel.

The Point Bridge at Pittsburgh that I built in 1875 has an 800-ft. span, piers 96 ft. high, in cement masonry resting on solid timber cribs built on gravel and well rip-rapped, and there is no sign of scouring.

The suspension bridge across the Allegheny River at Pittsburg, now torn down, built by Roebling 40 years ago, was built on timber cribs on gravel. They simply took a rake and raked the bottom clean and put down a timber foundation. Those rivers are exceedingly swift in high water and the water comes up very suddenly, and of course there is a very rapid current.

The only bridge in the Ohio River above Wheeling built on solid

rock is the bridge connecting the Pan Handle road with the Ft. Wayne road. I am therefore inclined to believe that if these piers had been built of good solid (cemented) masonry resting on a good crib built of 12 x 12-in. timbers, it would not have made much difference whether the middle of the river had been scoured out or not.

There is one thing here which I cannot quite understand. The author does not say much about it. How he erected that new draw span and at the same time worked the old pivot span and had to keep that draw in such a position that it could be moved for trains and boats. How he got the new draw in position on the new pivot pier, opening and closing the old every day, is something I don't understand.

W. H. GAHAGAN, Assoc. M. Am. Soc. C. E. (by letter).—Replying to Mr. Kelley's discussion of the settlement of the large trusses and why we did not take the sagging out of the temporary trusses by screwing up on the vertical rods, I would say that we did this very thing, and iron washer plates were put in over the gib plates and the nut put on again. This was done upon one rod at a time. We packed as much as 2½ to 3 ins. in this way, but were not able to do more than to hold and take up part of the shrinkage in the timbers. We could not lift the trusses with the rods after the dead load of the old spans was upon them.

All of this sagging could have been removed by blocking upon bents under the panel points (which had been removed); but it was not considered necessary to replace these bents.

By carefully examining the drawings and the dead load from the old spans to be carried, and the train load that was carried, it will be seen that these trusses needed to be very different from the ordinary type of Howe truss of the same span of which Mr. Kelley speaks.

In replying to Mr. Brendlinger, I would say that he is mistaken in regard to the scale of the drawings. They are all drawn to natural scale, the same horizontal as vertical, the scale being given upon each plate. By referring to Mr. Kelley's remarks, it will be noted that he calls attention to this fact in his discussion, and also notes the great amount of scour indicated between the piers. These scoured places between piers and below them are not exaggerated conditions, but are as shown on the plates. The old piers were setting upon gravel mounds, the contours of which are shown by examining plates LXXXIII and LXXXIV. The slopes or skin of these mounds were protected by rip-rap; and any one by examining these plates will see what would be likely to happen by disturbing the slopes or breaking the rip-rap skin upon them.

Nearly all of the piers of the bridge show a settlement on the down-stream end, some of them as much as 6 ins.; and to me it looked as though a very little disturbance of the down-stream slopes of old piers 7 and 9 might cause those slopes to slide at any time, and the pier to settle 1 ft. or more down stream, if the pier did not go to pieces entirely.

With regard to the history of the construction of the old bridge I

am not familiar, except that it was built 20 to 25 years ago, under conditions which certainly were very different from those existing to-day. Prices of material and work were many times what they are now; precedents and styles of construction were not so well fixed as they are to-day; and, possibly, this bridge could not have been built for lack of funds had an expensive type of construction been adopted.

The old foundation, as already stated, was built of logs framed into a crib. This crib was filled with rip-rap, and set on the gravel bed of the river, which was about 7 ft. below low water. The cut stone pile was placed upon this timber rip-rap crib. The piers as built had a batter of 1 in 12; and while the original constructors used no cement or mortar, the piers stood until they showed cracks from a settlement of the foundation which supported them.

In recent years, a later management thought to improve the condition of the piers by pouring cement grout into them. I examined these piers very closely while I was removing them, and they were not, and could not have been much improved by this grouting from the condition in which they were found. The grout in the first two or three courses at the top was good. It was hard and served as a rain cover to the portion of the pier below it. This portion of the grouting was valuable, but all below it might just as well have been left out, for it never set to become hard nor assisted to bind the pier together in any way. It was much like the tunnel Mr. Brendlinger spoke of, being grouted after being built.

The climate here is not as rugged as farther north, and masonry does not suffer much from frost.

The intention of the original constructor undoubtedly was to protect the foundation of these piers, as scour took place, by depositing rip-rap around them. This had been successfully followed, I understand, on all of the piers, until the Government objected to any more rip-rap being deposited around the draw rest and pivot piers, because it interfered with the passage of boats through the draw.

I cannot agree with Mr. Brendlinger in criticizing the style of design of this old work. It was built cheaply, and at an early day, when the traffic of the road was undoubtedly very light. It has, on the whole, done good service until it has been worn out, and the cause of the dangerous condition of the piers was not so much the fault of the designer as because the Government prevented the carrying out of the original method of protecting the foundations.

The current of the river during low water season is from 1½ to 2 miles per hour. The range between low and high water is about 49 ft. The speed of the current, I understand, at high water, varies in this portion of the river, *i. e.*, when the Ohio is low, and a heavy rise comes from the upper Tennessee. The current is very swift for this river—about 4 miles per hour. When the water in the Ohio is high, it has the effect of damming up the water in the Tennessee River

to some extent, and making a sluggish current at a very high stage of the river.

With regard to this old style of construction, I would say there is now, under my observation, in Idaho, a bridge 1 000 ft. long, of 10 Howe truss spans, crossing the Snake River. The current of the river is now 6½ miles per hour, and it is still more rapid at a higher stage of water. These bridges carry a heavy engine, which, with tender, weighs 195 000 lbs.

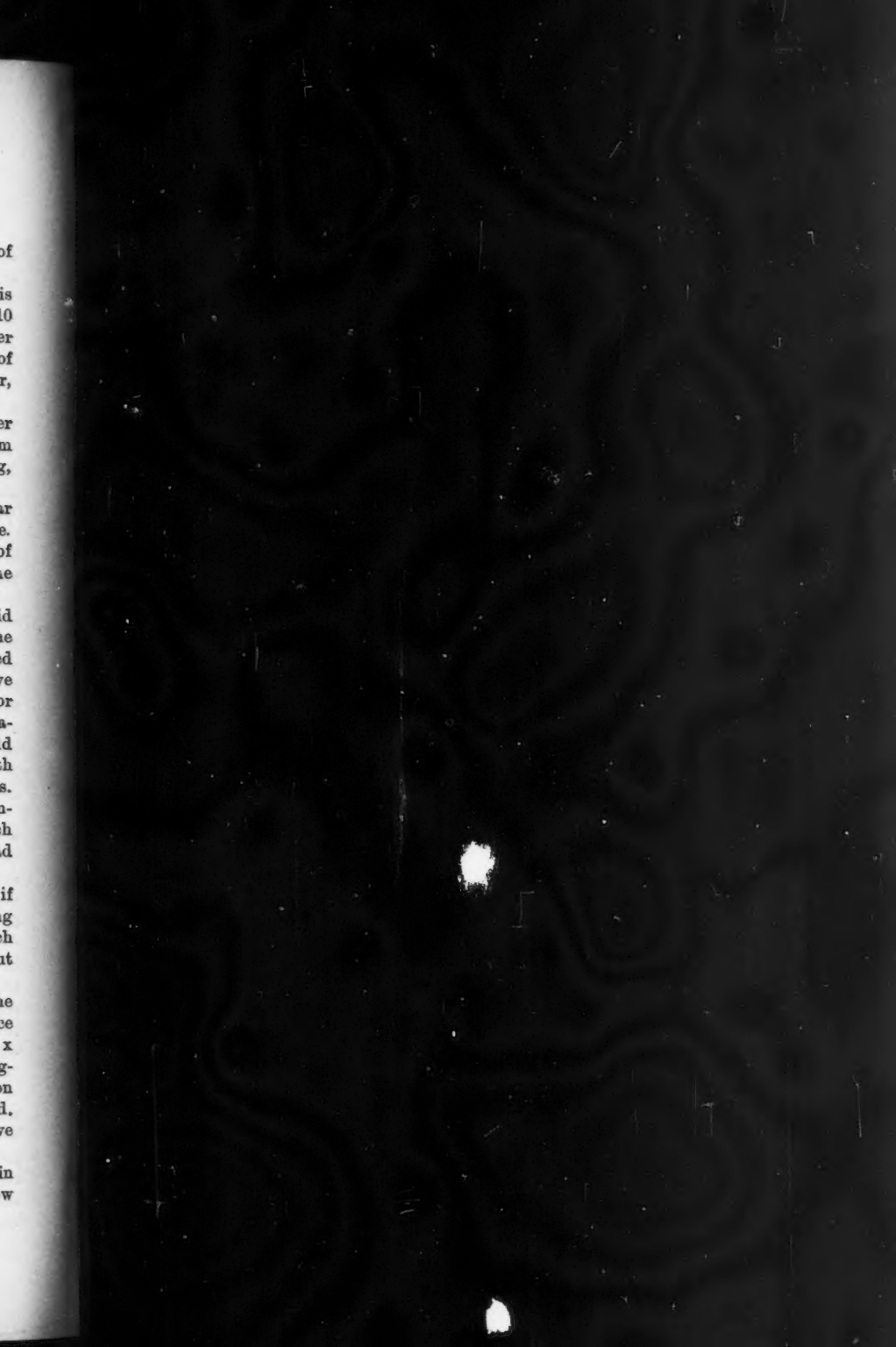
The foundations and piers for these bridges are framed timber cribs, which rest upon the bed of the river, and extend to the bottom chords of the trusses. These cribs are about 8 ft. wide, 30 ft. long, and about 25 to 30 ft. high.

They are filled with lava rock, which is abundant in the near vicinity. The rock is in pieces about the size one man can handle. The cribs are protected by rip-rap of this lava rock. The bottom of the river, between the piers, has scoured out as much as 20 ft. in some places since the piers were put in.

These bridges were built in 1883, at a time and place when it is said it required as large a force to provide for the commissary as to do the work. I am of the opinion that this and the style of foundation used by the Johnsonville builders was as good a construction as could have been adopted. The bridges have done the work required of them for their lifetime, and are now worn out, and it is doubtful if a more permanent style of construction for the foundations built at that time would not now have to be abandoned in putting in new superstructure, both from instability of the piers, and a rearrangement of the lengths of spans.

For these reasons, I think the original constructor of the Johnsonville bridge showed a good deal of skill in securing a structure which could be cheaply built, and which would carry the traffic of the road until there was need for something else.

Mr. Brendlinger says : "I am, therefore, inclined to believe that if these Johnsonville piers had been built of good, solid masonry, resting on a good crib, built of 12 x 12-in. timbers, it would not have made much difference whether the middle between the piers had been scoured out or not."

In some respects, I quite agree with Mr. Brendlinger, *i. e.*, the original spans should have been long enough not to materially reduce the section of the river, as has been done ; and the bottoms of the 12 x 12-in. timber cribs, he speaks of, should have been placed (by dredging the pier site) low enough to anticipate any scour from contraction of the channel, say, to a depth of 8 or 10 ft. below the old river bed. Had about 200-ft. spans been used, these old foundations could have been held, I think, by the method used by Mr. Brendlinger.

I had nothing to do with the erection of the iron work, but in answer to the question would say, that during the erection of the new draw, boats did not pass the bridge for six weeks.